Railway Trains in France Equipped with Wireless Apparatus

SCIENCE AND WAR—[See page 164]

War Psycho-Neurosis—I*
The Psychology of Soldiers' Dreams
By F. W. Mott, M. D., LL. D., F. R. S., F. R. C. P.,

ONE of the most striking symptoms of soldiers suffering with war psychoneuroses, whether commotional or emotional in origin, is the terrifying dreams which disturb the mind, and one of the most certain signs of improvement is sound sleep, the sweet unconscious quiet of the mind.

In books on psychology and psycho-analysis I find no reference to the psychology of soldiers' dreams. Yet, in that greatest of all works on human thought and action, we find reference to the dreams of soldiers and their significance so true to the present-day experiences that I shall refer to them and the possible classical source of their inspiration.

In the "De Rerum Naturæ" of Lucretius he says:

"And generally, to whatever pursuit a man is closely tied down and strongly attached, on whatever subject we have previously much dwelt, the mind having been put to a more than usual strain in it; during sleep we for the most part fancy that we are engaged in the same; lawyers think that they plead causes and even draw up covenants of sale, generals that they fight and engage in battle, sailors that they wage and carry on war with the winds. We think that we pursue our task and consign it when discovered to writings in our own native tongue. So all other arts and pursuits are seen for the most part during sleep to occupy and mock the minds of men."

Lucretius next calls attention to the evidence of dreams in animals:

"And often during soft repose the dogs of hunters do yet all at once throw about their legs and suddenly utter cries and repeatedly sniff the air with their nostrils as though they had found and were on the tracks of wild beasts."

In another passage Lucretius says:

"Again the minds of men which pursue great aims under great emotion often during sleep pursue and carry on the same in like manner; kings take by storm, are taken, join battle, raise a loud cry as if stabbed on the spot."

In Shakespeare there are two passages which may have had their source of inspiration in the "De Rerum Nature" of Lucretius—viz., the speech regarding Queen Mab by Mercutio and that of Lady Percy to Hotspur.

As Lucretius says, a man dreams of whatever pursuit he is closely tied down to; at the present day the soldier dreams that he is in the trenches fighting Germans, or he hears and sees the shells bursting, shouts in his sleep, and wakes with a start. How truly Shakespeare describes this when he says:

"Sometimes she [Queen Mab] driveth o'er a soldier's neck,
And then dreams he of cutting foreign throats,
Of breaches, ambuscadoes, Spanish blades,
Of healths five fathom deep; and then anon
Drums in his ear; at which he starts and wakes,
And, being thus frighted, swears a prayer or two
And sleeps again ...."

(In the quarto 1597 edition the text had "mines and countermines" instead of "Spanish blades," which seems singularly appropriate just now.)

In Lady Percy's speech to Hotspur there is the following passage:

"Why hast thou lost the fresh blood in thy cheeks¹
And given my treasures and my rights of thee¹
To thick-eyed musing and cursed melancholy?
In thy faint slumbers I by thee have watch'd
And heard thee murmur tales of iron wars:
Speak terms of manage to thy bounding steed,
Cry, 'Courage! to the field!' And then hast talk'd
Of sallies and retires; of trenches, tents;
Of palisades, frontiers, parapets;
Of basilisks, of cannon, culverin;
Of prisoners' ransom and of soldiers slain,
And all the currents of a heady fight,
Thy spirit within thee hath been so at war,
And thus hath so bestirr'd thee in thy sleep,
That beads of sweat have stood upon thy brow,
Like bubbles in a late-disturbed stream;
And in thy face strange motions have appear'd,
Such as we see when men restrain their breath
On some great sudden hest. O! what portents are these?"

(First Part of Henry IV., Act. II., Sc. III.).

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* A lecture delivered before the Psychiatric Section of the Royal Society of Medicine (Great Britain) and reproduced from The Lancet.

¹ Mr. Curdy, in discussing the Anxiety Neuroses of Soldiers, says:—"The man who is visited by his wife or his sweetheart is a disappointment both to himself and his visitor in that it is impossible for him to give any proof of his affection. This finds expression in a manifestly obvious way through the symptoms of impotence, which is, so far as I have been able to learn, universally present in the anxiety state, either as such, or in the form of its equivalent lack of erotic feeling."—"War Neuroses," Psychiatric Bulletin of New York, July, 1917.

The experiences of the war have shown us how true the psychology of Lucretius and Shakespeare is as regards soldiers' dreams and how utterly wrong the following statement of Brill, a follower of Freud, is:

"Dreams accompanied by fear are of a sexual nature; the ideation causing the fear in the dream was once a wish which was later subjected to repression."

And the two fundamental motives to human action are undoubtedly the preservation of the individual and the preservation of the species—that is, self-conservation and propagation.

SOLDIERS' DREAMS AND THE DOCTRINE OF FREUD.

The doctrine of Freud, and still more that taught by his followers, does not take into consideration, as a psychogenic factor of neuroses, the conflict caused by suppression of painful memories of experiences associated with the emotion of fear in relation to self-conservation. Long before the war I thought this was a weak point in the argument of the Freudians, for it leaves out of account this instinct.

Captain W. H. R. Rivers, in a recent interesting article, states:

"The denial of the validity of Freud's theory of the Unconscious in the form currently held by its adherents as the means of explaining nervous and mental disorders is, however, something very different from the denial of the validity of this theory altogether. Not a day of clinical experience passes in which Freud's theory may not be of practical use in diagnosis and treatment. The terrifying dreams, the sudden gusts of depression or restlessness, the cases of altered personality which are among the most characteristic of the present war, receive by far the most natural explanation as the result of war experience, which by some pathological process, often assisted later by conscious activity on the part of the patient, has been either dissociated or is in process of undergoing changes which will lead sooner or later to this result. While the results of warfare provide little experience in the favor of production of the functional nervous disorders by the activity of repressed sexual complexes, I believe they will afford abundant evidence in favor of the validity of Freud's theory of forgetting."

Instead of theories we should seek, however, some bio-chemical or bio-physical explanation why sudden emotional shock or continued emotional disturbance should produce an acquired emotivity in neuro-potentially sound individuals, as it undoubtedly does, although it must be admitted that in the majority of instances a pre-existing emotivity was present. The special merit of Freud's theory, according to Rivers, is that it provides a psychological theory of dissociation of the factors upon which it depends and of the processes by which its effects can be overcome. According to the views long current in psychology, experience is remembered in so far as it is frequently repeated and according as it is interesting and arouses emotion pleasant and unpleasant, and forgetting is a process which stands in no special need of explanation. The dreams of soldiers, some of which I will relate to you, exhibit in a striking manner how an incident of war associated with emotional shock is graven on the mind, for it continually recurs in a vivid and terrifying manner in their dreams, half-waking state, and in some few cases even in the waking state, constituting hallucinations. Forgetting this painful experience is a natural defensive reaction.

DREAMS IN RELATION TO THE UNCONSCIOUS.

The special merit, according to Rivers, of Freud's theory is that it affords an explanation of the mechanism of forgetting, and especially the forgetting of an unpleasant experience by a thrusting of it out of consciousness and keeping it out. This mechanism Freud terms the Censor, which is supposed to act as a constant guard, only permitting the arousing of the repressed experiences to reach consciousness in sleep, in the half-waking state, in hypnosis and automatic states in which the normal control of the censor is removed or weakened. Even in such states it is only permitted to become manifest in an indirect or symbolic manner. But does this hypothetical censor differ essentially from inhibition exercised by the highest centers of control, centers upon which voluntary attention depends? For voluntary attention would be made ineffectual by emotional perturbation. Consequently the inhibitory functions of the higher centers of control must be continually and,

after a variable time following the emotional shock, unconsciously exercised in repressing the recollection of the experience. At first during the conscious waking state the experience which caused the emotional shock crosses the threshold of consciousness in spite of the voluntary attempts of the patient to divert the mind, causing mental perturbation accompanied by visible emotional disturbances. The individual is conscious at first of this conflict, but its very continuance tends in the normal individual to make it pass into the unconscious. But this does not mean that the struggle is not going on; for every now and then the painful terrifying experience may in some cases rise into consciousness and cause marked emotional disturbance and depression.

DREAMS IN RELATION TO NEURASTHENIA OF SOLDIERS

As I have frequently observed, the persistence of terrifying dreams, often of one particular horrible experience recurring with great frequency, and even in the half-waking state persisting in the mind, proves that the struggle is going on. Indeed, experience shows that while these dreams persist the other signs of neurasthenia exist. Indeed, a prognosis of recovery largely depends upon whether the patient has refreshing sleep, undisturbed by these terrifying dreams. We may assume that these dreams cause a state of continuous emotivity.

Dejerine defines neurasthenia as the ensemble of phenomena which result from the non-adaptation of the individual to a continuous emotive cause and the struggle of the individual for this adaptation. Neural fatigue or nervous debility is neither neurasthenia nor hysteria, but if to the phenomena of fatigue there is superadded a state of continual emotivity upon which may be grafted an obsessing preoccupation, then, according to Dejerine, we are justified in diagnosing neurasthenia.

He also points out that the dream can even, in some cases, cause an emotivity if it introduces into consciousness images sufficiently vivid to be considered as an emotive excitation, and when persistent and terrifying as it is in the case of soldiers suffering with war psychoneuroses, an acquired emotivity may be engendered in a neuropotentially sound individual.

Dejerine admits the conflict as the cause of the psycho-neurosis, and points to the fact that a great number of functional neuroses may in a way be considered crystallizations of emotive phenomena. The emotion may be of internal or external origin, external emotive excitation creating what has been called emotive shock.

EMOTIONAL AND COMMOTIONAL SHOCK IN RELATION TO SOLDIERS' DREAMS

In a general way emotion is a reaction of the personality. Under intense emotional shock an individual may be deprived of even elemental perceptions; not seeing any more, not hearing any more, not feeling any more, transformed into a simple automaton, the subject, as Dejerine says, is, so to speak, in a state of psychological syncope. Soldiers under shell fire may become for the time being mere automata, and wander away unconscious of what they have been doing; it is difficult to decide whether they are suffering from emotional shock or from commotional shock without visible injury caused by forces generated by high explosives.

The emotional shock may be the result of terror or horror, and one must differentiate between these two forms of contemplative fear, in both of which the imagination plays an all-important part.

Sir Charles Bell says:

"Horror differs both from fear and terror, although more nearly allied to the last than the first. It is superior to both in this, that it is less imbued with personal alarm. It is more full of sympathy with the sufferings of others than engaged with our own. We are struck with horror even at the spectacle of artificial distress, but it is peculiarly excited by the real danger or pain of another. Horror is full of energy; the body is in the utmost tension, not unnerved by fear."

Terror is more self-regarding; horror is more altruistic. Both sentiments are based upon the primitive emotion of fear.

The character of the dreams of soldiers shows that they are imbued with terror or horror, sometimes with both.

FREUD'S THEORY OF THE UNCONSCIOUS IN RELATION TO THE DREAMS OF SOLDIERS

The special characteristic of Freud's theory of the unconscious is active repression of a painful experience, and his doctrine of the part taken by such repressive experience in the production of bodily and mental disorder is the principal feature of Freud's theory in its relation to psycho-neuroses; for many morbid mental and bodily states are due, according to Freud, to a conflict between repressed experiences, now usually called complexes, and the general personality of the sufferer.

Freud, and especially his followers, have only seen the sexual aspect of Freud's theory, and they have only regarded sexuality as its basic principle. But the experience gained since the war shows that this position is no longer tenable.

My experience regarding the infrequency of a sexual basis of neurasthenia and hysteria occurring in the case of soldiers returning from the front agrees with that of many other observers, but again I quote the words of Captain Rivers for two reasons: firstly, because a statement by an eminent psychologist who has studied the question practically affords a strong support to my observations; and, secondly, it is further strengthened by the fact that many of the officers who were under my care for a time subsequently came under his careful observation. Rivers says:

"In my own experience cases arising out of the war which illustrate the Freudian theory directly and obviously have been few and far between. Since the army at the present time would be fairly representative of the whole male population of the country, this failure to discover to any great extent the cases with which the literature of the Freudian school abounds might well be regarded as significant.

"We now have abundant evidence that those forms of paralysis and contracture, phobias, and obsessions, which are regarded by Freud and his disciples as preeminently the result of repressed sexual tendencies, occur freely in persons whose sexual life seems to be wholly normal."

THE INBORN AND ACQUIRED FACTORS OF EMOTIVITY

We have over and over again abundant evidence that pathological neuroses and mental states are due directly to the shocks and strains of war.

There are certain facts to consider upon which reliable premises may be founded. They are as follows: (a) Every individual has a personality depending upon the inborn factor, the raw material he was born with, which is a complex depending upon species, race and family. (b) What has happened since birth.

My experience now based upon statistics proves conclusively that by far the most important factor in the genesis of war psycho-neuroses is an inborn or acquired tendency to emotivity. The family and personal history of 100 cases of war psycho-neurosis without visible injury compared with 100 cases of shrapnel, gunshot, and other bodily injuries under the surgeon's care, made by an American officer, Captain Wolfsohn, at my suggestion, at the Fourth London Hospital, show a striking difference in the comparative frequency of an inborn neuropathic or psychopathic tendency or temperamental timidity in the two groups. However, my experience coincides with that of Rivers in the fact that commotional and emotional shocks and stress of modern trench warfare may be the direct cause of an acquired emotivity in a neuropotentially sound individual, and this emotivity may manifest itself in the form of neurasthenia, hysteria, psychasthenia, as well as confusional, stuporose, demential, hallucinatory, maniacal and depressional states, from which, however, as a rule they make a complete recovery.

Stress of trench warfare eventually lowers the resistance of the normal individual to shock, whether it be emotional or commotional.

It is not uncommon to find a good soldier or officer under the excitement of battle "carrying on" after he has been blown up by a shell and even rendered for a short time unconscious or dazed, but a few days later breaking down and developing a psycho-neurosis. Experience has shown that he is unfit as a rule for general service for six months. How can emotional shock be differentiated from commotional shock? The latter is often complicated and intensified by the former happening at the time of the commotion, and the dreams of soldiers prove this.

Commotion may produce vascular changes and minute hemorrhages which are scattered through the grey matter of the cerebro-spinal axis in some cases. There is a demonstrable physical change, for the pressure of the cerebro-spinal fluid is increased; there is often hyperalbuminosis, and in severe cases, as one would expect, blood may be found in the fluid. The French lay stress upon the Voltaic vertigo test which is present in the great majority of cases of commotional shock. Moreover, a fair percentage are deaf on the side upon which the shell exploded, and examination may show a ruptured drum. How does emotional shock act? Very probably the endocrine glands, especially the adrenal and thyroid, are profoundly influenced by emotional shock, and the persistence in the subconscious mind of memories of experiences associated with terror or horror is revealed by the dreams of war experiences.

SECRETO-MOTOR REACTIONS THE OUTCOME OF SUPPRESSING FEAR DURING THE WAKING STATE

The subconscious memories of war experiences connected with fear and the self-conservative instinct are probably continually acting upon the lower cerebrospinal and sympathetic secreto-motor, bulbo-spinal, and autonomic centers, accounting for many of the secretory and motor phenomena observed in war psycho-neuroses. The motor disorders and disabilities met with in soldiers suffering from emotional or commotional shock are frequently of the nature of instinctive defensive reactions. Thus, a tic of the head has acquired the name of the "dodging reflex," being the spontaneous movement which would take place upon hearing a shell coming; this tic is especially liable to be excited by any sudden noise or sound. Again, many of the motor paralyses and disabilities we know to be associated with fear by popular metaphor. Thus, "dumb with fear," "quaking or trembling with fear," "paralysed by fear," and the crouching attitude of many "shell shock" cases suggests the defensive reaction of concealment by immobility—in contradistinction to that by flight or fight. In these latter conditions an increased discharge of muscular energy is required, a rise of blood pressure, and an increased quantity of glycogen is converted into sugar. This is effected through the splanchnic nerves exciting an increased mobilization of adrenalin from the suprarenal glands.

A very common vaso-motor phenomenon exhibited by soldiers suffering with shock, especially those who are troubled with terrifying dreams, is acro-cyanosis, coldblueness of the extremities, hence the popular expression of "blue funk." In about 10 per cent. of severe cases of shock there are signs of Graves's disease—viz., some degree of exophthalmos, von Graefe's sign, Möbius's sign, tachycardia, and fine rhythmical tremors 8 or 9 per second, and the thyroid gland is more easily palpable than normal.

SECRETO-MOTOR REACTIONS THE OUTCOME OF TERRIFYING DREAMS

Many of my cases were unable to recollect their dreams, but complained of waking up in a fright and in a cold sweat. Kant[a] explains this by saying that:

"In the waking state we do not remember any of the ideas which we might have had in sound sleep. From this last follows, however, only this much, that the ideas were not clearly represented while we were waking up, but not that they were obscure also while we slept."

Further, he says:

"I rather suppose that ideas in sleep may be clearer and broader than even the clearest in the waking state. For man at such time is not sensible of his body. When he wakes up his body is not associated with the ideas of his sleep, so that it cannot be a means of recalling this former state of thought to consciousness in such a way as to make it appear to belong to one and the same person. A confirmation of my idea of sound sleep is found in the activity of some who walk in their sleep, and who in such a state betray more intelligence than usual, although in waking up they do not remember anything."

In the dreams of soldiers, when the perceptual relations of the body to the external world are dissociated and the inhibitory functions of the highest cortical centers of voluntary attention are in abeyance, ideas of past war experiences are revived with great vividness in the great majority of cases, even in those who are unable to recollect their dreams. For besides those cases which wake up in a fright and cold sweat, there have been numerous instances of soldiers who have walked in their sleep and many others who have talked, shouted out orders and cried out in alarm as if again engaged in battle; some of these have been mutes. But the strangest phenomena of forgotten dreams of soldiers suffering with shock are observed in those who in their sleep act as though they were back in the trenches engaged in battle, and go through all the pantomime of fighting with bomb, with bayonet, with machine gun and with rifle, and yet remember nothing of these happenings when they awaken. One or two cases of this kind had to sleep in the padded room in order to prevent them doing injury to themselves. Evidently during

[a] Dreams of a Spirit Seer.

their sleep vivid imaginings of their previous experiences are arousing defensive and offensive reactions in face of the imaginary enemy.

As these dreams cease to disturb sleep, so these manifestations of fear tend to pass off and give place to the sweet unconscious quiet of the mind. Occasionally during the waking state contemplation of the horrors seen provokes hallucinations or illusions which may lead to motor delirium or insane conduct. At least this is the interpretation I should put upon the symptomatology of the two following illustrative cases:

1. A captain, aged 20, was admitted under my care in a state of restless motor delirium; he moved continually in the bed, sat up, passing his hand across his forehead as if he were witnessing some horrifying sight, and muttering to himself; yet, when interrogated, he answered quite rationally. This motor delirium I associated with the continuous effects on the conscious and subconscious mind of the terrible experiences he had gone through. His whole company had been destroyed, and, while talking to a brother officer, the latter had half his head blown off by a piece of a shell. The patient improved very much, but a relapse occurred after a night disturbed by terrifying dreams. Even after a year had elapsed his nervous system showed a marked emotivity and he had to be boarded out of the service.

2. *Paroxysmal attacks of maniacal excitement following shell shock.*—A young man, aged 19, was admitted suffering with shock due to emotional stress and shell fire. He suffered with terrifying dreams, and after he had been in hospital a short time he developed sudden paroxysmal attacks of maniacal excitement. The first attack occurred suddenly. One afternoon he had been helping as usual in the kitchen, and then he went and lay down on his bed and apparently went to sleep; he suddenly woke with a startled, terrified look, became flushed in the face, sweated profusely, and made for the door as if to get away from some terrifying conditions. He was with difficulty restrained. He remained in this excited state, glaring rapidly from side to side, giving one the impression that he was suffering from terrifying hallucinations of sight and hearing, although he would make no response to interrogation. He did not recognize his wife, the doctor, or the sisters. Once when I, accompanied by two medical officers in uniform (strangers), came up to speak to him he became violently agitated as if some terrifying conditions had been aroused by the sight of the uniforms; the face was flushed and he sweated so profusely that the perspiration dripped in a stream off his nose. The attacks would last from a few hours to a few days; they came on quite suddenly like an epileptic fit and often without any apparent cause. They became more severe and frequent, and when we had moved the neurasthenic patients to the Grove-lane schools he one day ran out of the building into the playground and attempted to get over the wall. He was brought back and I saw him sitting in the ward on his bed; his head was buried in his hands; I spoke to him; he immediately got up, looked at me in the most terrified manner, and made for the door; it required four orderlies to restrain him, and he fought and kicked violently, exhibiting much strength and nervous energy. Much to my regret I found it necessary to have him sent to Napsbury. I have heard that he has made a complete recovery and been discharged. It may be mentioned that there was no history obtainable of epilepsy or insanity in the family.

This case rather suggests the psychic equivalents of epilepsy in the attacks.

[TO BE CONTINUED]

Cloud Photography

A METHOD recommended for cloud photography consists in the use of a device made up of a mirror of black glass mounted in a special frame and placed in front of the camera lens, so that the photograph will be taken from the mirror and the brilliant light of the clouds will be thus diminished. However, it is difficult to procure such black glass mirrors in ordinary trade, but it is comparatively easy to make a suitable mirror. This is done by taking a piece of clear glass such as is used for making mirrors and roughening one side after the manner of ground glass. On this latter side is applied a coating of black varnish made of Judaea bitumen. This avoids the double reflection which would be produced by using ordinary glass and simply putting on a coat of varnish. The time of exposure is of course, much longer than in the usual way and may be from $\frac{1}{4}$ to $\frac{1}{15}$ second when well stopped down. It is claimed that this arrangement allows of obtaining details of clouds which cannot be had otherwise by the most improved plates and screens.

Red Sandal Wood

RED sandal (*Pterocarpus santalinus*, Linn., f.) was formerly valued for the red coloring matter santalin found in the heart-wood, and was exported to Europe from Madras in large quantities for use as a dye. This use outside India has been superseded by aniline dyes, and the wood is now used for the construction of house-posts, as it is never attacked by white ants. The tree grows on the slopes of the Cuddapah and neighboring hills in the Madras Presidency.—*Nature*.

Press Illustrating Service

A big rotary snow plow ready for service

Press Illustrating Service

A "rotary" eating its way through a deep drift

Fighting Snow Drifts on the Railways

THE severity of the winter that is now passing into history calls attention to the methods adopted by the railways for contending with one of the most serious obstacles to transportation, and the matter comes home to us all the more strongly because of the unusual amount of snow that has fallen in regions that are not usually so greatly afflicted.

In the mountain regions of the West, where the tracks are not only exposed to the direct fall of snow, but are constantly in danger for several months during the winter from avalanches from the overhanging mountain sides, it is customary to seek protection by erecting immensely strong sheds over the tracks, frequently for miles at a stretch. At first these were constructed of heavy timbers, strongly anchored to the mountain side by great bolts of steel and with the roofs slanting up to the adjoining slope to divert and pass the torrent of sliding snow and rocks over and beyond the line. These sheds have proved very effective in protecting the most critical points; but the wooden construction involved the constant danger from fire, so that of late there has been a tendency to substitute concrete for wood, notwithstanding its greater cost.

In the open country, where driving snow is liable to form deep and solid drifts, special forms of fences are placed on the side of the track toward the prevailing winter winds to intercept the snow, and to compel it to build up a protecting wall.

It is not, however, feasible nor desirable to attempt to cover or guard the entire trackage of our railways by the above means, and when there is an unusually heavy fall of snow great drifts frequently form in unexpected places, and deep cuttings are filled to the top. Where such conditions are prevalent recourse is had to plows of various kinds; and in the Western country, where heavy snowfalls are the rule, the most efficient weapon employed is the rotary plow, such as is shown in the illustrations on this page. This machine consists of an extremely heavy and strong car that carries at its front end a great fan-shaped wheel, strongly built of steel, with the leading edges of the fan blades constructed to cut the snow as the wheel is steadily revolved by a powerful engine within the plow car. As the snow is thus excavated it is passed to a chamber behind the fan wheel, where is located a fast revolving fan blower that ejects the snow with great force through a shoot in the roof of the car and thus throws it far off to one side of the tracks.

This plow car is not self-propelling, but is pushed forward gradually by as many locomotives as may be necessary, coupled at the rear, the speed of advance being regulated by signals from the "snow pilot," who is posted at the front of the plow.

The field of these monster snow-fighters is west of the Mississippi, but during January, when whole freight trains, standing on sidings, were entirely buried in snow, it became necessary to bring some of them into the Eastern country, where they rendered splendid service.

Science and War

RAPID communication is one of the essentials of a military campaign, and every known method, from the conspicuous "wig-wag" system with flags to the radio is constantly employed by our armies. The illustration on the first page shows two railway trains in France

equipped with wireless apparatus. This kind of aerial is much more cumbersome than the apparatus that has been tried out on a few trains in this country, but it has the advantage that it is simple, and can be quickly put in place as occasion requires. The trains shown are evidently railway batteries, with large guns permanently mounted on armored cars, which can be quickly moved to any required position reached by the tracks, and the firing of the guns can be readily directed by instructions sent either from aeroplanes or captive balloons.

The Use of the Microscope in Engineering

THIS was the subject of a paper read before the Manchester Association of Engineers by Mr. W. E. W. Millington, Wh. Ex. The paper was confined to the use of the instrument for the examination of the structure of metals, and so important does the author consider this microscopical analysis that he would, generally speaking, prefer it to a chemical analysis, especially in connection with foundry work. After some remarks on the subject of metallography, in which he described a mechanical mixture, a solid solution, a chemical compound, and the use of the equilibrium or constitutional diagram, the author proceeded to describe the necessary apparatus, which is quite inexpensive, and consists of a microscope without any elaborations, with a vertical illuminator for high power work inserted in the microscopic tube. The latter is so arranged that light from an external source is reflected down through the objective lens itself onto the specimen. From the surface of the specimen some of the light is reflected back through the objective up the microscope tube into the eyepiece. The source of light may be daylight—not direct sunlight—a good incandescent gas light, or a suitable electric light. The author himself generally uses a low voltage half-watt electric light, surrounded by an opaque cover in which is cut a hole of suitable size for illuminating purposes. This cover keeps the glare of the light from the eyes when using the instrument. A bull's-eye condenser is advisable for use in concentrating the external light on the vertical illuminator. Two-inch, 1-inch, ½-inch and 1/6-inch objectives for the microscope give ample range for ordinary work, especially if used in conjunction with, say, three eyepieces of different magnifying powers. The only other apparatus really necessary is the polishing materials and the etching re-agents.

For ordinary photographic work, inexpensive arrangements can be made which give quite satisfactory results. For example, an apparatus which has been used by the author consists of an ordinary quarter-plate camera mounted on a board, which is held in a vice used for scleroscope work. In place of the camera lens an extension tube has been fitted, in order to obtain 15 inches between the plate in the camera and the eyepiece of the microscope. The connection between the extension tube and the microscope tube is, of course, made light tight. For focusing, the ordinary ground glass of the camera should be replaced by a piece of plain glass. Rough focussing can be done by laying a piece of ground glass on the top of the plain glass, and the final focussing by resting on the plain glass one of the microscope eyepieces and looking through it. The total cost is about £34. The author has found that specimens ⅞-inch square section, and ¾-inch deep, are very suitable.

After having cut out the specimen, the surface to be examined should be filed or ground level and finished off smooth. If the grinding process is used, great care must be taken that the surface is not overheated, as heat may entirely change the structure of the metal near the surface. After having thus obtained a level and reasonably smooth surface, free from deep scratches, the polishing process is commenced by rubbing the surface on emery paper of gradually increasing degrees of fineness, commencing with No. 0 and then No. 00, No. 000, and finally No. 0000. Care should be taken that the direction of rubbing on one paper is at right angles to the direction on the preceding paper, and that the rubbing is continued on one paper until all the scratches produced by the previous process have been removed. After finishing on the No. 0000 paper the specimen should have a very good surface; which requires very little to complete the polishing operation. The final polishing has to be carried out on a soft pad, using a very fine material as the abrasive.

Certain examinations can be made with the specimen in the unetched condition. For example, examinations for porosity, for foreign matter such as slag, and for lead in gunmetal can be made on the unetched surface. Generally speaking, however, it is necessary to treat the surface in some way in order to bring out the structure by producing differential treatment of the various constituents. Certain structures can be developed by carefully heating the specimen until different constituents take on different oxidation tints and then by rapidly cooling the specimen, so as to arrest the oxidation. The most common method, however, of bringing out the structure is by etching the surface of the specimen by means of some re-agent which attacks the different constituents to different extents.

The etching re-agent can be applied to the surface by means of a camel hair brush, or the specimen can be completely immersed in the re-agent. The extent to which the etching should be carried can only be learned from actual experience. When it is judged that the etching process has been carried far enough, the specimen should be quickly put in a stream of water and thoroughly washed, and afterwards should again have the surface washed with alcohol, in order to dry it thoroughly.

The author has found that the following are the most useful etching re-agents for ordinary work: Iron and steel: A 5 per cent. solution of picric acid in alcohol. Brasses: A solution of 2 per cent. chromic acid, 5 per cent. sulphuric acid, 93 per cent. water. Bronzes: A solution of 80 per cent. of a solution of one part of ferric chloride in 12 parts of water, 20 per cent. concentrated hydrochloric acid. The paper was illustrated by a large number of lantern slides.—The Engineer.

New Plant, Isopyrum Fumarioides, Yielding Hydrogen Cyanide

THE Siberian plant, *Isopyrum fumarioides*, L. (*Ranunculaceae*), is one of the most strongly cyanogenetic known; a 100-grm. sample, representing all parts of the plant, yielded 0.249 grm. of hydrogen cyanide on digestion with water for several hours at 25°—30° C. A much smaller amount, 0.042 grm., had previously been obtained from *I. thalictroides*, the only European plant of the same genus.—Note in *J. Soc. Chem. Ind.* on an article by M. MIRANDE in *Comptes Rend.*

The Crust of the Earth*

Its Composition and Structure

By Stanley C. Bailey, A.M.I.C.E., F.G.S.

THE crust or surface of the earth for a limited depth is formed of various materials, including rocks and minerals, consisting of arenaceous, argillaceous, carbonaceous, calcareous, silicious and metallic constituents, which are known by various names according to their chemical composition or mechanical combination.

This crust is believed to be about thirty miles thick, and forms therefore about 1/263.7 of the mean diameter of the earth, which is 7,912.4 miles.

If the earth is represented by a sphere 16.4 inches in diameter, the 30 miles of crust which is formed of known materials will consist of a layer only 1/16-inch in thickness, and what is below this is quite unknown; but it has been shown by calculation that the interior of the earth must be composed of a material having a high specific gravity and great tenacity, so that it is possible that it may consist of iron in some form of chemical combination with other metals, for iron is the most abundant mineral in nature, and the earth itself is a great magnet.

The average specific gravity of the earth is given by various authorities as follows, viz.:—Cavendish, 5.48; Reich, 5.44; Bailly, 5.67; Ordnance Survey, 5.31; Poynting, 5.49, and Boys, 5.53; which is an average of 5.488; or in other words, the average weight of the earth is about 5.488 times the weight of fresh water, which is 1,000 ounces, or 62.5 pounds per cubic foot, at sea level, and at a temperature of 60 deg. Fahr.; thus the earth weighs 343 pounds per cubic foot on an average.

Now the surface rocks forming the crust have an average specific gravity of 2.5, or weight of 156.25 pounds per cubic foot, so that the maximum specific gravity deep down in the earth must be some figure approaching 8.4, or 525 pounds per cubic foot in weight.

Pure iron has a specific gravity of 7.5, which is equivalent to 468.75 pounds per cubic foot, while that of steel is 7.85, or a weight of 490.6 pounds per cubic foot. Nickel, which is one of the constituents of meteorites, has a specific gravity of 8.28, or weight of 517.5 pounds per cubic foot, while the rare metals are over double this weight; but a mass of iron weighing 1,000 pounds on the surface of the earth would only weigh about 500 pounds at a depth of 2,000 miles in the interior of the earth. The change from the character of the surface materials to those in the interior is probably a very gradual one, so that there is no really definite line of demarcation that can be drawn between the so-called "crust" and the unknown interior.

It has been estimated by Professor Phillips that the crust is chiefly composed of the following elements, chemically and mechanically combined in various ways, viz.:—Oxygen, 50 parts per 100; silicon, 25; aluminum, 6; calcium, 5; iron, 4; magnesium, 3; sodium, 2.5; potassium, 2.5; and other elements, such as carbon, hydrogen, sulphur, and chlorine, 2.0.

The meteors known as Holosiderites are composed almost entirely of metallic iron with nickel, and a small quantity of carbides, sulphides, and phosphides. One which fell in Mexico some years ago consisted of 96.5 per cent. of iron and 3.5 per cent. of nickel; while others known as Asiderites are formed of stony and mineral materials, such as augite, olivine, chromite, and magnetite. The former have probably come from the interior of some planetary body which has disintegrated, and the latter from the exterior portions of the body. These facts tend to corroborate the theory that the main bulk of the earth is composed of iron in some form or other. Of the known elements, about twenty are found in meteorites.

The highest mountains on the earth are the following, viz.:—Mount Everest, in the Himalayas, 29,002 feet (5.49 miles); Kanchanganga, 28,150 feet (5.33 miles); and Dhaulagiri, 26,828 feet (5.08 miles); and in the Andes the highest peak is Aconcagua, 24,000 feet (4.54 miles), or an average of about five miles above mean sea level. The deepest portions of the seas have been found in the following positions, viz., at a distance of about forty-six miles off the northern coast of the island of Mindanao, in the Philippine group, where a depth of 32,089 feet (6.07 miles) was sounded.

On the east of the island of Guam, in the Marianne group, the United States of America cable ship "Nero" found a depth of 31,614 feet (six miles nearly). This is now known as the "Nero Deep."

Off the northeast coast of Japan a depth of 27,930

Various dislocations and contortions exhibited in geological formation

feet has been obtained, and 27,450 feet south of the Ladrone Islands.

In a model globe 16.4 inches in diameter, representing the earth, where 1/16-inch is equivalent to 30 miles, a height of five miles would be represented by 1/96-inch, which is about the thickness of a sheet of thick paper; so that although the highest mountains and the deepest seas appear to be enormous to us, they are nothing more than slight creases on the surface of the earth.

A mass of iron when cooled from a red-heat, say of 1,470° F., to a normal temperature of 60° F. contracts about 1/107 of its length, and assuming that the earth has contracted to a similar extent from a red heat, the total contraction would amount to about 74.6 miles, which would give the original mean diameter as 7,987 miles.

The effect of this contraction has been to dislocate the crust or surface formations and produce folds, much in the same way as the skin of a dried apple is wrinkled when it shrinks, the ridges of the folds become mountains in the case of the earth, and the hollows are the valleys, while the isolated and elongated islands in the seas are the tops of submarine mountains, which have their corresponding valleys in the deepest parts of the seas.

Many oceanic and marine islands, such as Ascension,

Trinidad, Teneriffe, Samoa, Fiji, Hawaii, New Hebrides, Solomon Islands, Lipari, Bourbon, and Stromboli, are the cones of great volcanoes, the tops of which project above the sea level; while all dry lands, islands, and continents may be considered as the upper portions of mountains which have their valleys below sea level. A comparison of the greatest elevations and depressions on the surface of the earth, with those on the moon, shows that those on the latter are much greater when compared with the respective sizes of these bodies.

The moon is 2,153 miles in diameter, and would be represented by a globe 4.48 inches in diameter on a scale of 30 miles to 1/16-inch, and yet its highest mountain peaks, which have been measured by the lengths of the shadows cast on the floors of the craters, have been found to be about five miles in height, while the valleys are about four miles deep.
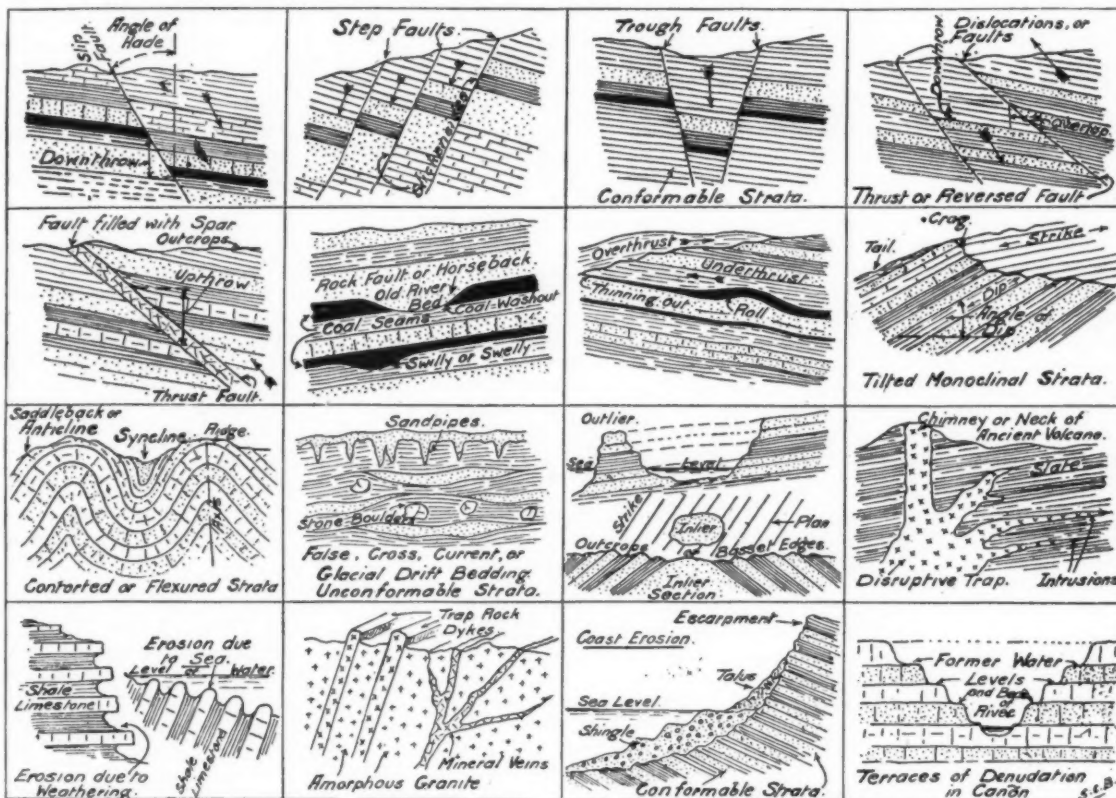
The ringed plains of Clavius and Grimaldi, which were probably at one time the craters of great volcanoes, are 142 and 138 miles ,respectively, in diameter.

The crater of Cyrillus is 60 miles in diameter, and the walls are 15,000 feet high; that of Catharina is 65 miles in diameter with walls 13,000 feet high; while that of Plateau is 70 miles in diameter, with walls 8,000 feet above the floor of the crater. The peaks of Dörfel have a height of 26,690 feet (5.05 miles), those of Clavius 24,000 feet (4.54 miles), and the Ramparts of Newton 23,853 feet (4.51 miles).

The largest crater rings on the earth are in central Italy; they are now lakes, but were at one time the necks of volcanoes. One of these, the Lago di Bracciano, which is 22 miles northwest of Rome, is 6½ miles in diameter, while the other, the Lago di Bolsena, which is about 35 miles from Rome, is oval in shape, and 10¼ miles by 9 miles.

The outer crater ring of the island of St. Helena is about four miles by eight miles, and is horseshoe - shaped, the wall on one portion having been broken down.

These dimensions show what enormous forces must have been at work at one time, both on the earth and the moon, to produce such large volcanoes; while at the present time it has been estimated that there are about 2,000 volcanic eruptions per 100 years. The total thickness of the various known strata forming the crust of the earth has been estimated as follows, viz.:—Tertiary, 2 miles; Cretaceous, 2.5; Jurassic, 1; Triassic, 0.75; Permian, 0.75; Carboniferous, 4; Devonian, 2.5; Silurian, 6; Ordovician and Cambrian, 5.5; Huronian, 2; Laurentian and Metamorphic, 6 miles; a total of 32 miles. These formations are not superimposed upon one another to these total depths, but are spread over the earth in varying thicknesses. For instance, there may be one mile of upper Carboniferous rocks in one country, two miles of middle Carboniferous in another, and two miles of lower Carboniferous in a third, or there may be portions of each of the three sections of the Carboniferous in one country, and those beds that are missing may be found in some other parts of the world. The crust of the earth is never completely at rest anywhere, for there are constant slippings of strata, due in some cases to the higher angle of inclination, especially on mountain slopes, and in others, to the action of water percolating through and lubricating the strata.

*From The English Mechanic.

or in saturating the ground, as seen in the bog slides.

Earthquakes caused by dynamic and volcanic forces produce movement and dislocation of otherwise fairly stable strata; in some countries the land is rising, while in others it is sinking; for instance the coast of Friesland and the northern portions of Holland have been found to be sinking at the rate of 3 inches, 6 inches, 8 inches and 10 inches per 100 years in various parts; while the north coast of Germany is estimated to be subsiding at the rate of 12 inches per century. Earthquakes usually originate at depths of about seven or eight miles, and their origin never exceeds a depth of thirty miles. Active volcanoes are usually situated near the sea, and are probably due to the sea water percolating through fissures on the coast into subterranean cavities, where the heat converts it into superheated steam at a very high pressure, the rocks in the immediate vicinity are melted, and the steam forces its way out through the points of least resistance in the superincumbent strata, shaking and splitting the ground, and carrying molten materials with it, thus producing earthquakes and a volcanic eruption.

The average rate of increase of temperature, or "Geotherm," is about 1° Fahr. for every 50 to 60 feet of descent into the ground, but the rate varies considerably in various countries and districts according to the nature of the strata passed through, the presence of water and oil in the borings, and proximity to volcanoes; it is also not uniform: for example, in a boring at Paris down to a depth of 740 feet the rate of increase was 1° F. per 50 feet of descent, while from 740 to 1,600 feet it was 1° F. per 75 feet.

In a boring at Sperenberg, near Berlin, down to 1,900 feet, the rate was 1° F. per 55 feet, and from 1,900 to 4,170 feet it was 1° F. per 62.5 feet, the surface temperature being 47.8° F., and that at the bottom 118.6° F.

In a boring 4,500 feet deep, sunk near Wheeling, West Virginia, U. S. A., the rate was 1° F. per 80 to 90 feet of descent in the upper portion, and 1° F. per 60 feet in the lower part, the surface temperature being 51.3° F. and that at the bottom 110.3° F.

At Schladabach, near Leipzig, in a boring 5,740 feet deep, the rate was 1° F. per 68.6 feet, the surface temperature was 51.9° F., and that at the bottom 135.5° F., while at Pittsburg, Peter's Creek, U. S. A., at a depth of 5,380 feet the bottom temperature was 120.9° F., and that at the surface 51° F., which gives an average rise of 1° F., per 76.9 feet of descent.

It has been found that where there are oil-bearing strata, the temperature increases per unit of depth at a rapid rate, and the richer the beds are in oil the higher is the rate; in volcanic districts also the rate increases to 1° F. per 24 feet in depth, which at a depth of 5,112 feet, or nearly a mile, would amount to 213° F., which is the boiling point of sea water; while cast iron, which melts at about 2,000° F., would be in a molten state at 48,000 feet, or 9.9 miles.

With regard to the effects of pressure on rocks, it is observed that granites will fracture at three to four tons per square inch and crush at from four to six tons per square inch; hard limestones will crush at three tons per square inch, sandstones at two to three tons per square inch, while soft limestone will not carry more than from one to one and a half tons per square inch without crushing.

Sandstone rocks weighing 150 pounds per cubic foot would exert a pressure of 353.5 tons per square foot, or 2.45 tons per square inch at a depth of a mile, while at a depth of five miles the pressure will be 1,767.5 tons per square foot, or 12.25 tons per square inch, which is quite sufficient to produce contortion of the strata, and even a flow of the rocks under high mountains, such as the Himalayas, Alps, and Rocky Mountains.

In an experiment made on Carrara marble by Prof. F. D. Adams at Montreal University, the marble (which under ordinary conditions crushed at from 11,430 to 12,026 pounds per square inch, or 5.38 tons, which is equivalent to 774.72 tons per square foot), when placed in a Low Moor iron tube ¼ inch thick, and subjected to heat and pressure, withstood a load of 18,000 pounds per square inch, or 8.03 tons, which is equal to 1,156.32 tons per square foot.

The marble flowed and adhered to the surface of the tube firmly, and under the microscope the rock structure resembled that of gneiss.

The middle of the St. Gothard Tunnel is 5,733 feet below the top of the mountain, and the rocks encountered consisted of granite, gneiss, and schists. Assuming these rocks to weigh 160 pounds per cubic foot, the pressure would amount to 409.5 tons per square foot, or 2.84 tons per square inch, or very nearly the fracturing pressure of granite; as a matter of fact, numerous fissures were met with in boring the tunnel, from which

large quantities of water gushed out. During the construction of the Great Hartberg Tunnel, in the Austrian Alps, considerable pressures were encountered in the decomposed gneiss and Tertiary rocks, so much so that the timbering of the headings had to be rapidly proceeded with after the excavation.

The pressure at the bottom of the deepest seas, which are in places six miles in depth, is 905.1 tons per square foot, or 6.28 tons per square inch, taking the weight of sea water at 64 pounds per cubic foot.

One would have thought that this great pressure would be sufficient to convert the ooze into a hard rock, but it is not so, the mud being so flocculent that it is held in suspension in the water for a considerable depth, so that the water forces its way into fissures at the bottom of the sea, and drives back any fresh water coming from the land through the faults and porous strata, thus assisting in producing geysers o boiling water mixed with sulphur, other mineral matter, and gases picked up during the passage of the water through the ground. It is a well-known fact that the level of fresh water in borings and wells near the sea rises at high water and falls as the tide ebbs.

The result of the great compression of the strata, especially under mountains, is that there is always a tendency to crush under the highest portions and to force the lower surrounding country outwards on the lines of least resistance; thus tension and shearing action takes place at the bases of mountains. This is particularly the case where mountains have steep slopes, and the most severe earthquakes invariably occur on such slopes, while flat and undulating country is comparatively free from seismic disturbance. Submarine earthquakes are probably due to a similar cause, and the sudden rising or lowering of the sea bottom produces violent commotion on the surface, resulting in great rushes of water, that are erroneously termed "tidal waves."

The effect of earth pressure may sometimes be observed in railway embankments over peaty or boggy ground, where the weight of the bank will force the soil out on each side in waves parallel to the bank. Another cause of earthquake is said to be the wearing down of the land by atmospheric agency, and the deposition of the soil on lower ground, and on the seashores, but this is probably not a serious contributory cause, for if such was the case every country would be subject to constant earth shocks; but, as a matter of fact, the proximity of high mountains to deep seas tends to produce the most frequent and severest shocks, due to the yielding of the ground under unequal stress. Volcanic action also causes earth shocks, but not to a great extent; for instance, in Central Japan there are numerous active volcanoes, and yet this portion of the country is comparatively free from severe quakes, which are much more frequent on the eastern shores near the sea.

The continuity of the strata and rocks in every country is much broken by numerous faults or slipping of the ground upwards and downwards along the planes of the faults; these faults, which often open out and develop into fissures, generally lie in fairly straight lines; often they are in parallel rows, but may be in any direction. This is especially the case in the carboniferous limestone and the coal measures, but in the Igneous rocks they are more frequently in parallel lines.

The fissures, in time, become filled with minerals, and are then known as "mineral veins," "lodes," or "ore veins." Some are filled with spar and carbonate of lime, and others with sulphur, sand, earth, etc.

In volcanic regions they become filled with lava, basalt, hornblende, greenstone, or diorite and dolerite, and are then known as "dykes"; these also often contain minerals. In many cases the faults have occurred at various periods, the first fractures being perhaps subsequently filled with tin; at a later epoch cross faults have developed; these may become filled with copper; while at a still later era other fractures may have formed which may contain either iron pyrites, zinc, or lead ores.

In some instances the original fissures have widened at various times, and alternate layers of different metallic ores are then found to fill them. Earthquakes are not always due to volcanic action, but more often have a dynamic origin, and faults are more often due to earthquakes than to volcanoes; nevertheless, some of the greatest faults are in the neighborhood of past and present volcanic activity, but it is probable that the faults in most cases occurred first, and that the admission of water through the fissures started the dormant igneous action by producing great volumes of steam at high pressures.

Faults extend for varying distances on the surface

of the earth, from a few miles to hundreds of miles in length, but to what depths they descend is a matter of conjecture.

A great fault, nearly seventy miles long, and with a maximum vertical throw or displacement of 9 to 18 feet, occurred during the great earthquake in Nippon, Japan, in October, 1891; it extended almost across the island of Nippon.

During a severe quake in the State of Sonora, Mexico, in May, 1887, two great faults developed, one on each side of the Sierra Teras mountains, near the Arizona boundary; that on the western side was forty miles long, and the maximum vertical displacement was 11 feet. This appears to have been what is known as a "thrust fault," the mountain being pressed upwards.

In June, 1897, there was a severe shock in northeast Bengal, which resulted in a fracture twelve miles long, having a maximum vertical throw of 30 feet.

In the Californian earthquakes of 1868 and 1906 the shocks followed the great San Andreas fault, which extends along the coast, at the foot of the coast range of mountains from Point Arena, north of San Francisco, to San Juan Bautista in the south, a distance of 200 miles, and they produced a total extension of the land towards the sea amounting in some places to 10 feet. Similar extensions have been observed as a result of the Assam earthquake of 1897.

The primary shocks of some earthquakes have been found to travel at the rate of about 7 miles per second, or 25,200 miles per hour, thus encircling the earth in that time. This confirms the existence of a deep-seated material having nearly twice the density of steel; the secondary shocks travel at about 3 miles per second (10,800 miles per hour), and the tertiary at about 2 miles per second (7,200 miles per hour), thus showing that the succeeding shocks are nearer the surface. Another cause of the dislocation of the earth's crust is to be found in the large accumulations of water, oil, and gases, at considerable depths and under high pressures. Where coal, coal shales, and sandstones are overlaid by thick beds of clay there are often large quntities of gas and oil, and the presence of natural geysers of boiling water and steam at a temperature of from 270° Fahr. to 340° Fahr. in various parts of the world shows that the heat and pressure must be considerable, for the water is thrown in some cases over 200 feet into the air at pressures of from 75 to over 100 pounds per square inch. In a colliery in the Newcastle district so much as 4,900 cubic feet of gas has been evolved from the coal in three minutes, while in another colliery 1,500 cubic feet was continuously given out every two hours.

Geologists and miners have assigned various names to the different forms of dislocation of the crust of the earth. For instance, "faults" are also known as "slips," "hitches," and "shifts," the angle of the fracture made with a vertical line is called the "hade," and the "throw" of a fault is the vetrical height through which the beds have risen or the length through which they have fallen; if they have risen, the fractures are called "upthrow," "reversed," "overthrust," or "thrust" faults. These are due to compression, the beds being pushed over one another, thus producing contraction of the land; should the beds have fallen, they are known as "downthrow" faults. These are caused by tensional stress.

"Stepped" faults are parallel ones, with a throw at each fracture, and "trough" faults are parallel ones, in which the land between them has sunk; in "cross" faults the fractures intersect one another in various directions. The striated and often polished surfaces of faults in hard rock are termed "slickensides," and the direction of the striations indicates in which way the ground movements have taken place.

The throws or vertical displacements of some faults are very great. For instance, in the "90-fathom dyke" of the Newcastle coal measures the seams of coal are 540 feet lower on the northern side of the fracture than they are on the southern side. This great fault, which has a width of about 60 feet, has become filled with sand, which has hardened and consolidated into a wall or dyke of sandstone.

In connection with inclined strata, the angle it makes with a horizontal line is called the "dip," and is the complement of the "hade," or the angle made with a vertical line, and the direction of the strata at right angles to the dip is known as the "strike." For instance, certain beds may dip 10 degrees from north to south; the strike of the beds across the country will then be east-and-west. Level strata, which are seldom met with, have neither dip nor strike.

The illustrations show the various dislocations and contortions that are exhibited in geological formations, with the names applied to them.

The Bacterial Treatment of Sewage

THE attempts which were made and the hopes which were entertained some twenty-three years ago with regard to the complete disposal of sewage (apart from screenings and inorganic matter) by contact beds or by the aid of septic tanks would, in the light of such knowledge as we then possessed, appear to have been fully justified. It was clear from experiments which had been carried out that not only could effluents free from the possibility of secondary putrefaction and containing only small amounts of suspended matter be discharged, but that the more objectionable matters contained in sewage could, generally speaking, be readily oxidized under conditions afforded by coke beds; in fact, that so far as such matters were concerned it was possible to effect a maximum reduction with a minimum of offense. It is hardly remarkable, therefore, that the charging of contact beds with crude sewage appeared as a correct, economical and inoffensive means of disposal. But the science of bacteriology was in its infancy, and it was not recognized that sewage contained large quantities of matter resistant to bacterial action and requiring long periods for its disintegration.

As a consequence, accumulations of stable organic and mineral matter took place within the body of the beds, which the method of operating failed to remove; a condition which was intensified in the case of some of the earlier beds by faulty construction and imperfect methods of working.

The septic tank proved itself capable of transforming and gasifying the more resistant matter in sewage, but the length of time necessary for such operation to be carried to completion was again lost sight of, and the exaggerated expectations as to sludge reduction with which it was introduced were not realized. But the comparative failure of the septic tank would appear to have arisen more from design than idea. The incoming sewage was kept in contact with putrefying sludge for a long period, with the result that the effluent was fouled, and often charged with large quantities of suspended matter owing to the active fermentation taking place, or the volume of sludge deposited in the tank. The sludging of these tanks was, moreover, a highly offensive operation owing to the absence of proper means insuring the withdrawal of only fully digested matter.

But although the septic tank failed to solve the sludge difficulty, sludge reduction was effected in amounts variously estimated as from 10 per cent. to 40 per cent., which was a distinct gain. Unfortunately the work was accomplished under conditions which gave rise to considerable nuisance, and which, so far as after-treatment was concerned, increased both the offensiveness of distribution and the difficulties of filtration.

More modern forms of tanks have proved the possibility of carrying out such work equally well with an almost perfect freedom from the objections associated with septic tanks. The suspended solids can be effectually and quickly separated and preserved from contact with the bulk of the liquid, thus allowing the latter to be distributed on the filters when comparatively fresh (or, in the rare cases admitting of direct discharge into rivers, in a condition making less immediate demands on the oxygen dissolved in the river water), while the accumulated sludge can be retained and gradually drawn off when fully digested, the manner of its withdrawal insuring the maximum bacterial activity owing to movement caused in the entire mass at the time of sludging, and the consequent presentation of new surfaces to the action of the organisms by which it is inhabited. But the failure which marked these early attempts at sewage disposal by direct bacterial action was comparative only, and the result of imperfect knowledge, and credit is alike due to those who attempted by means of a purely ærobic action, or by the aid of an anærobic preliminary, to solve the sludge difficulty, and who laid the foundation for intensive biological treatment in this country.

The advent of the trickling filter, a device which admitted "the quick oxidation of putrescible matters while allowing the larger body of stable matters or those rendered stable by filtration to pass through," marked a considerable advance.

While possessing some defects, the trickling filter was free from many of those which characterized contact beds. Difficulties arising from clogging were largely overcome, as this form of filter displayed the power of evacuating matters which had accumulated in the bed in a very marked degree, more especially during times of maximum bacterial activity. Moreover, the effluents discharged were superior and more even in quality, larger volumes of sewage were dealt with, and there was an absence of confusion of ærobic and anærobic action, which arose in connection with the

earlier method of working contact beds when long periods of contact were allowed.[1]

But in spite of the considerable advance which was made it became increasingly evident that beds and filters must be further protected, and that while it was possible by bacterial treatment to convert an ill-smelling, objectionable liquid into one free from odor and putrefying matter, provision for the disposal of sludge must remain an important factor in the design of sewage works, and the idea of sewage disposal was gradually displaced by one which aimed at the modification of sewage without offense.

And in this connection it came to be recognized that while the efficiency of filters from which the final effluent was to be released demanded the further removal of suspended matter, the offensiveness or inoffensiveness of such operation depended both upon the manner of separation and the condition of the separated matter on its discharge, and that while it was necessary for accumulations to take place, such accumulations should consist almost entirely of relatively stable organic or mineral matter, and need not be complicated by those of an easily changing and putrefying character. Further developments in this direction not only proved the possibility of effecting separation without unduly retarding the flow of sewage, but led to the adoption of measures whereby either sufficient stability was given to the suspended matter in the early stages of treatment to allow of its removal from the immediate site of the works in a nonputrefactive condition, or whereby it was held back after separation until fully digested. In the latter direction much useful work has been done and considerable ingenuity displayed.

Slate beds and hydrolitic and Imhoff tanks each fulfilled some or all of the requirements necessary to the satisfactory carrying out of such preliminary work. Slate beds involved the holding up of the sewage and proved slow in operation, but they permitted the discharge of an effluent which was easy of treatment and sludge which was readily dried, and which, in the absence of unnecessary delay, gave no cause for offense. The hydrolitic tank, which was the outcome of much careful experiment, proved a most effectual means of rapidly bringing down suspended solids, and recognized for the first time the possibility of entangling and precipitating colloidal and other non-settling matters, but it unfortunately possessed the defects of allowing a certain volume of the inflowing sewage to pass through the sludge-digesting chamber, and of discharging the arrested suspended matter in a putrefying condition. At the time of its inception the importance of avoiding contact between the fresh sewage and the deposited sludge was perhaps not sufficiently appreciated, but the discharging of putrefactive matter was an obvious and unnecessary blemish, and it appears surprising that the inventors of this form of tank should have left it to others to make the necessary improvements and reap benefits to which they would appear to have been entitled.

The Imhoff tank, while making no provision for the removal of colloidal matter, prevents contact of the inflowing sewage with the deposited sludge, and retains the latter until reduced to a nonputrefactive condition. The sludge discharged is distinguished by a relatively small percentage of moisture, possesses the capability of readily drying, and is, generally speaking, free from offense. This form of tank has been very largely adopted in works for the treatment of sewage in America.

During a period of years work in connection with biological treatment was marked rather by efforts towards increasing the efficiency of existing methods than by the introduction of anything strikingly new, and apart from that relating to such subjects as the elimination of fat, the reduction of moisture in sludge or the sterilization of effluents, there was little to

[1] It has been pointed out in a report in reference to work carried out at the Lawrence Experimental Station that the success or otherwise of the ordinary bacterial filter must be regarded very largely as a matter of requirements. If, in addition to the discharge of a satisfactory effluent, it is considered sufficient to oxidize the putrescible organic matter and at the same time avoid the retention of the stable organic matters, then a device which can accomplish a large amount of such work on a comparatively small area must be regarded as a success. If, on the other hand, there is a demand for the complete removal of organic matter both stable and unstable, then sand filters, or those of similar material, are the only ones which can satisfy such requirements.

Further referring to the fact that the ultimate disposition of matters in suspension is the chief difficulty in successful sewage treatment, the report states that in the Massachusetts sewage, while from 50 per cent. to 75 per cent. of such matters is organic, only from 1 per cent. to 7 per cent. or 8 per cent. of that amount is nitrogen—rarely more than 2½ per cent.—the remainder, or approximately 96 per cent. or 97 per cent., being carbonaceous, resistant to bacterial action and slow to putrefy or decay.

record, but early in 1914 Dr. Gilbert Fowler referred to the possibility of purifying sewage in tanks without further aid of filters, while at the same time obtaining both an inoffensive sludge of some manurial value and a well-ærated effluent. Since that date the treatment of sewage by "aeration and activated sludge" (which appears to give considerable promise) has developed with astonishing rapidity.—*Engineering.*

Experiments on Tribo-Electricity

IT is strange that tribo-electricity—that is, the subject which deals with the production of charges by rubbing together unlike materials—has been so greatly neglected by experimentalists during the last century. A dozen branches of electricity have, during that period, been developed to the dignity of voluminous quantitative sciences, whilst this section of the subject, which is of great antiquity, can be dealt with on a page or two of a text-book, and consists of incoherent qualitative facts.

A recent paper by Dr. P. E. Shaw (Proc. Roy. Soc., November, 1917) discloses interesting results, and indicates that this neglected field of research is being developed. Throughout the experiments described the conditions of the surfaces used were varied systematically—by rise of temperature before and during friction; by treatment when flexed; and by previously grinding or polishing, and so on. It is well known that there are condensed films on the surfaces of many solid materials. Little is understood as to the nature or depth of these adsorbed layers, but they have proved a veritable stumbling-block to the investigator of certain phenomena—*e. g.* surface-tension and photo-electricity. But these films have little influence on tribo-electric effects, for here there is always a rough impact of solid on solid, the films are penetrated, and the true solid surfaces bear on one another.

The tribo-electric series consists of thirty-six places in order from the extreme + at top to the extreme — at bottom. The outstanding feature of the present results is the readiness with which a solid changes its place in the series when its surface condition is changed by heat, abrasion, flexure, and the like. Thus ordinary soda-glass drops from place 5 to place 21 when made matt, and to place 26 when its temperature has been raised to 245° C. Mica, which normally occupies place 6, drops to place 18 when matt, and to place 26 when heated to 270°. On the other hand, ebonite rises from place 28 to place 27 when matt, and to place 21 when heated to 100°. The remarkable character of these changes is that they are not erratic, but follow a simple law, as follows: All materials in the series above place 14 fall when rendered matt or after heating; but all materials in the series below 14 have the contrary tendency, and rise when heated or made matt. Thus the tendency is for the two ends of the series to come together as a result of these changes of condition. The temperature at which the change by heat occurs is quite definite for each material, and has been found for some sixteen metals and non-metals. It ranges from 70° C. to 300° C.

Dr. Shaw considers that this diametrically opposite behavior in the + and — groups of the series indicates the existence of two kinds of atom or atomic group, one kind for each group, the difference between the two kinds being fundamental. But whatever form the theory of these effects may take, these new facts can scarcely fail to be of great importance. The research provides an explanation of the well-known readiness with which materials change their tribo-electric character. It should now be possible to avoid, in great measure, the confusion and irregularity which have hitherto characterized the subject.—*Nature.*

Some Peculiarities in the Manufacture of Chrome Steel in the Martin Furnace

IN the author's experience, the chromium content of the metal produced in the Martin furnace depends entirely on the operation of the furnace and not on the initial chromium content of the charge. The high loss of chromium (often two-thirds of the total) experienced in ordinary working occurs mainly during fusion particularly if the atmosphere is sufficiently oxidizing. When fusion is complete the chromium content of the metal bath increases with the temperature at which the operation is continued. The author is of opinion that, at high temperatures the chromium of the slag passes into the metal in the form of an oxide (other than that present in the slag), which is very stable and soluble under these conditions.—From a note in *Jour. Soc. Chem. Ind.* in an article by N. N. MENCHIKH in *Rev. Soc. russe de Mét*
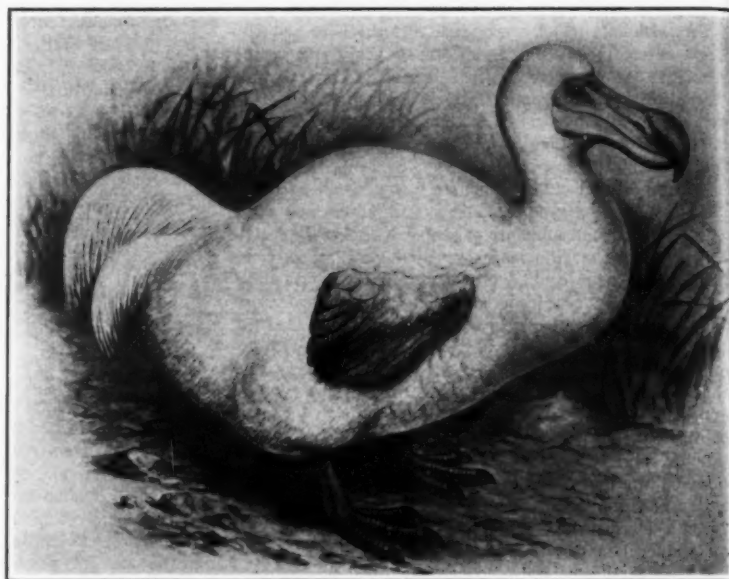
Fig. 1. The Dodo: by the author after Rothschild

Fig. 2. The Dodo of Reunion: by the author after Rothschild

Anomalies of the Animal World—Part VIII
The Dodo and Other Flightless Birds
By Dr. R. W. Shufeldt

ONE has often heard of the far-famed Dodo, and ornithologists are more or less familiar with the little that is known of its near relative, the Dodo of the Island of Réunion. Both of these birds are now extinct, and both were entirely flightless. They were remotely related to the pigeons—indeed they formed a group of very specialized pigeons, the Dodo being named *Didus cucullatus*, and its Réunion relative *D. solitarius*. Colored plates are given us by Rothschild in his "Extinct Birds," with a great many outline drawings of dodos from almost as many sources. The colored plates have been copied by my camera, and are reproduced here in Figs. 1 and 2, the first being the Dodo and the second the Réunion Dodo.

In the other volume referred to, Rothschild says of *D. cucullatus* that the "first description of this very remarkable bird was given in the account of the voyage of Admiral Jacob van Neck in 1598, which was published by Corneille Nicolas at Amsterdam in 1601. It is as follows: "Blue parrots are very numerous there, as well as other birds; among which are a kind, conspicuous for their size, larger than swans, with huge heads only half covered with skin as if clothed with a hood. These birds lack wings, in place of which 3 or 4 blackish feathers protrude. The tail consists of a few soft incurved feathers, which are ash colored. These we used to call 'Walghvögel,' for the reason that the longer and oftener they were cooked the less soft and more insipid eating they became. Nevertheless their belly and breast were of a pleasant flavor and easily masticated."

Fig. 5. Aphanapteryx Bonasia: by the author after Rothschild

In a large number of works on travel and voyages published in the 17th and 18th centuries we find all sorts of notices about the Dodo and numerous pictures of which I have given outline drawings. From these sources it appears that the Dodo became extinct about the end of the 17th century, *i. e.*, 1680-1690. The cause of the extermination of this, perhaps the best known

and most talked about of the recently extinct birds, are not far to seek. The total inability of flight, the heavy, slow gait, and the uttter fearlessness from all immunity from enemies, led to a continual slaughter for food by the sailors and others who came to and dwelt on Mauritius. But the final cause of extermination of this and many other birds in the Mascarene Islands was probably the introduction of pigs, and also of the Ceylon monkey. These animals increased enormously in numbers, ran wild in the woods, and soon destroyed all the eggs and young birds they could find."

Fig. 4. Pezophaps Solitaria: by the author after Rothschild

This bird was at least twice brought to Europe alive (1599), and they furnished some of the information and some of the pictures we have of the species.

As for the Réunion Dodo, it has not been long extinct, comparatively speaking; nevertheless we have, unfortunately, but little knowledge of it by way of history. It was first mentioned by Mr. Tatton in his "Purchas his Pilgrimes," and he says of it: "There is store of land fowle both small and great, plenty of Doves, great Parrats, and such like; and a great fowle of the bignesse of a Turkie, very fat, and so short winged, that they cannot fly, being white, and in a manner tame; and so be all other fowles, as having not been troubled nor feared with shot. Our men did

beat them down with sticks and stones. Ten men may take fowle enough to serve fortie men a day."

This Réunion Dodo seems to have been confused with other birds also called Dodos (*Solitaires*) and named *Didus solitarius;* to my mind, Rothschild has not untangled this in his "Extinct Birds." In this work, under *Didus solitarius* (Réunion Dodo, p. 175), he gives this name, not only to the bird here shown in Fig. 2, but also to another, here reproduced in Fig. 3 from his Plate 25 A. This was a very remarkable bird that became extinct between the years 1735 and 1801; Fig. 3 is evidently the bird described by the early explorers and others on the Island of Bourbon or Réunion, referred to by Newton (Art. "*Solitaire*") in his *Dictionary of Birds* (p. 887).

According to Rothschild, the specimen in Fig. 2 is "from a Dutch picture taken from the living bird in Amsterdam" (beak and wing restored); while the one shown in Fig. 3 is "from Dubois' description." Newton's *Dictionary* appeared in 1896 and Rothschild's "Extinct Birds" in 1907; from the bibliography in the latter it would appear that Fig. 2 is now to be accepted for the Réunion Dodo.

Another extinct and flightless bird is another Solitaire (*Pezophaps solitarius*) which inhabited the Island of Rodrigues. Plate 23 of Rothschild's "Extinct Birds" is devoted to it, and it is here shown in Fig. 4. having been copied photographically by me for the purpose.

Leguat first described this bird in 1708; they were taller than turkeys, the males being of a brownish-gray color. Their wings were only used to beat the sides of their bodies during their peculiar dances or in
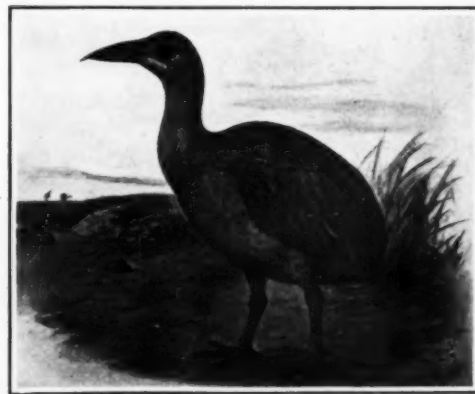

Fig. 6. Erythromachus legauti: by the author after Rothschild

making the loud noise they did to call one another. This noise sounded like a rattle and could be heard at a distance of 600 yards or more. Leguat's description of this bird is most interesting, and its habits were entirely different from any bird now living; it is too

Fig 9.   Apterornis coerulescens: by the author after Rothschild

long, however, to reproduce here, even in part, but one will find it given nearly in full in Rothschild's work as noted above (pp. 177-179).

Still another flightless bird, now extinct, is the *Aphanapteryx bonasia* (Fig. 5 from Rothschild's Pl. 29). According to Frauenfeld, this species—which was an inhabitant of the Island of Mauritius—was "the size of a fowl, of a uniform brown red all over. Bill and legs dark. Iris yellow. Feathers decomposed, as in the *Apteryx*, somewhat lengthened on the nape."

There appears to have been a living specimen of this bird about 1610 in the Imperial Menagerie at Ebersdorf.

It is not so difficult to understand why the birds we call rails should, in certain instances, lose the power of flight, and their descendants, perhaps, exhibit atrophy of the wings. They are marsh birds of feeble structure that in many instances have but slight excuse, except during migration, to take to wing. We have numerous small rails in our existing avifauna, as the Sora Rail, and others. The extinct flightless and gigantic moorhen of Mauritius was related to these (*Leguatia gigantea*), and a figure of this bird is given in my article in *Century Magazine* (Jan., 1884). That figure was reproduced with my permission by Captain Oliver in his work "The Voyage of François Leguat of Bresse to Rodriguez, Mauritius, Java, and the Cape of Good Hope" (works issued by The Hakluyt Society, London, 1891, Vol. II, p. 360).

A more rail-like bird of the Rodriguez Island was *Erythromachus leguati* of Milne-Edward. This is shown in Plate 30 of Rothschild's "Extinct Birds," and here reproduced by me in Fig. 6. As a species now known it is called the Rodriguez flightless rail. It is quite extinct.

Leguat said of these birds: "Our 'gelinotes' are fat all the year round and of a most delicate taste. Their

Fig. 8.   Notornis hochstetteri: by the author after Rothschild

Fig. 3   The Solitaire: by the author after Rothschild

color is always of a bright grey, and there is very little difference in plumage between the two sexes. They hide their nests so well that we could not find them out, and consequently did not taste their eggs. They have a red naked area round their eyes, their beaks are straight and pointed, near two and two-fifths inches long, and red also. They cannot fly, their fat makes them too heavy for it. If you offer them anything red, they are so angry they will fly at you to catch it out of your hand, and in the heat of the combat we had an opportunity to take them with ease."

Then there are the extinct and probably flightless little rails of the genus *Pennula*, of which *P. sandwichensis* of the Sandwich Islands was one (Roth. E. B. Pl. 26, Fig. 2, rep. in Fig. 7 herewith), and it is to be regretted that the limitations of space allow but a passing notice of these interesting birds here.

Among flightless, or very nearly flightless, existing rails, there are several genera and species to be noted, as for example those of the genera *Ocydromus, Habroptila, Megacrex*, and others. Those of the first-named

Fig. 7.   Pennula sandwichensis: by the author after Rothschild

occur in the islands of New Zealand; the second in the Moluccas, and the last in South New Guinea (Fly River). Some of these birds have the wings of fair size, while the power to use them is almost entirely wanting (*Ocydromus*, "Weka Rail"). Dr. Richmond tells me that *Porzanula palmeri* of Laysan Island is another flightless rail, and it is likely that other species in other parts of the world are in the same plight.

Two species of *Ocydromus* of New Zealand are now extinct, as is *Cabalus modestus* of the Chatham Islands. The latter was a flightless rail, and probably the other two were. Indeed, there is good reason to believe that many rails and rail-like birds were either very weak flyers or else entirely lacking in that power. Many birds became extinct because they were flightless, and fell as prey to man and other animals. We must pass these by for the lack of space to notice them, as is unfortunately the case with respect to some few representatives of other families and genera.

We have next to invite attention to a most interesting assemblage of birds that are either quite flightless or nearly so, and are—or in most instances were—found

Fig. 11.   The Owl Parrot: by the author after G. R. Gray

on islands of the New Zealand group. They belong to the genera *Notornis, Apterornis*, and others, and have affinities with the existing Coots (*Fulica*) and Gallinules (*Porphyrio*, etc.). There is quite an extensive literature on these birds and an interesting one. Rothschild presents figures—or rather colored plates—of a number of them in his "Extinct Birds," and a few of these are reproduced by me here, through the aid of my camera.

Notornis hochstetteri is now probably extinct, as it was on the very verge of extinction some fifteen years ago. It was a beautiful dark purple bird, with iridescent deep green back, and white under tail coverts. The bill and feet were a coral red. Its appearance, shown in Fig. 8, is copied from Rothschild. Only four or five skins of it have been preserved, two of which are in the British Museum. Its habitat was South Island, New Zealand. There are at least three other species of *Notornis* extinct, the best known being Mantell's, and none of them were capable of flight.

The following is from a popular work on natural history in my library, which says that in 1849 "a party of seal hunters, who were pursuing their avocations in Dusky Bay, having observed the trail of a bird in the snow with which the ground was then covered, determined to give chase. Proceeding in the direction of the footsteps, they at last caught sight of the object of their pursuit. Their dogs gave chase, and finally, after a long hunt, the bird was captured alive, in the gully of a sound behind Resolution Island. It ran with great speed, uttered loud cries, and violently attacked the dogs. But, notwithstanding the long struggle, it was caught uninjured and taken on board ship, where, after having been kept alive for three days, it was at length killed and eaten, the sailors who partook of the meal describing the bird as most delicious food. For-

Fig. 10.   Extinct flightless Parrot of Mauritius: by the author after Rothschild

tunately, these nautical epicures, who certainly were no great naturalists, did not pluck their bird, but skinned it, and Mr. Walter Mantell, son of the celebrated geologist, Dr. Mantell, being there, procured it, and thus we have a tolerably correct account of the bird. It was evidently a species of rail, somewhat larger than a common fowl; the head, neck, breast, and flanks were of a brilliant purple; the back of a dark olive. It could not fly, but ran with great swiftness." This was a specimen, according to this account, of *Notornis mantelli.*

Related to this last genus we have the flightless and now extinct *Apterornis coerulescens*, which was to be found on Bourbon or Réunion Island. They were known to Le Sieur D. B. (Dubois) as the *"Oyseaux bleus,"* and his original description runs thus: "As big as the Solitaires; they have the plumage entirely blue, the beak and the feet red and made like those of fowls; they do not fly at all but run extremely quickly, so that a dog can hardly catch them; they are very good."

Rothschild devotes colored Plate 32 to this bird in his "Extinct Birds," and this is here shown in Fig. 9, being reproduced from my photograph of the Plate. Other genera are *Aptornis* and *Palaeolimnas;* of these we only possess skeletal remains, but enough to demonstrate their affinities with the coots and gallinules.

There is still abundant in tropical South America a remarkable bird known as the Hoactzin or Hoatzin (*Opisthocomus cristatus*); it is about the size of a partridge and it lives in bands in the lower trees and shrubs along the lagoons and rivers, very rarely taking to wing. As a matter of fact, the subadult individuals are almost flightless, while the young, in crawling about through the twigs with their hands and feet, remind us very much of certain lizards.

Curiously enough, we also have flightless parrots to describe, for most birds of this group—and there are a very great many of them—are excellent flyers. Owen first described the blue "broad-billed parrot" of Mauritius, which has probably been extinct for over three centuries. (Fig. 10 from Roth. E. B., Pl. 7). He only had two mandibles to go by (1866), which was later on, as pointed out by Rothschild, greatly added to by Professor Schlegel who "discovered in the Library of Utrecht the manuscript journal kept during the voyage to Mauritius in A. D. 1601-1602 of Wolphart Harmanszoon, in which among other items of natural history there is a sketch of *Lophopsittacus* from life, and the statement that it was wholly of a grey-blue color. From the fact that this bird is not mentioned by the voyagers who visited Mauritius in the second and third decades of the 18th century, it is probable that it was one of the first of the Mascarene birds to become extinct. This is easily understood when we consider that the bird was apparently unable to fly, and would like all big parrots prove excellent eating."

There is a most remarkable parrot still in existence in New Zealand which is practically a flightless species, being able only to take "short flights on an incline." This bird is known as the "Night-Parrot" or "Owl-Parrot," and by others as the "Ground-Parrot," while the Maori name for the bird is "Kakapo." Science has given it the name of *Stringops habroptilus*, and it has been known since 1843, having first been described by Dieffenbach in his "Travels in N. Zealand" (p. 194). There is a fine colored plate of it in "The Genera of Birds" by G. R. Gray (vol. II, London, 1844-1849, Pl. CV.), to which Doctor C. W. Richmond of the National Museum invited my attention, and which was photographically copied by me and here reproduced in Fig. 11.

Nearly all the large museums now have skins of this bird, and it has been kept alive for comparatively brief periods in the London "Zoo." Alfred Newton says (Dict. of B.): "Though much has been written about it, there is no detailed description of its internal structure, a fact the more to be regretted since the bird is obviously doomed to early extinction, and the opportunity of solving several problems of interest, which a minute examination of its anatomy might afford, will be lost if the matter be not speedily taken in hand" (p. 474).

Usually this species is a nocturnal one in habit, but there have been exceptions to the rule. It lives entirely upon a vegetable diet, and remains in holes in trees or under rocks during the daytime. Sometimes it will *climb* into a tree, but it generally remains upon the ground where *introduced* animals are now rapidly exterminating it.

"The Kakapo is about the size of a Raven, of a green or brownish-green color, thickly freckled and irregularly barred with dark brown and dashed here and there with longitudinal stripes of light yellow. Examples are subject to much variation in color and shade, and in some of the lower parts are deeply tinged with yellow. Externally the most striking feature of the bird is its head, armed with a powerful beak, that it well knows how to use, and its face clothed with hairs and elongated feathers that sufficiently resemble the physiognomy of an owl to justify the generic name bestowed upon it. Of its internal structure little has been described, and that not always correctly." (Dict. of Birds, pp. 474-475.)

Some authors make two species of this bird, namely the one dscribed above and *S. greyi.*

"Rail-Creep"*

By Frank Reeves, M. Inst. C. E.

It occurred to the author some years ago that light might be thrown on the cause of rail-creep by making a few simple experiments.

He began by passing a wooden wheel several times in succession, in one direction, over a planed white-pine lath resting on a hardwood bench, and found to his surprise the lath had moved bodily about two millimetres in the direction of travel, the total amount of the latter having been about fourteen metres. Up to that time the author, in common with many other railway engineers, had held the opinion that creep was probably in the main due to temperature changes, assisted by the movement of trains.

He, therefore, made a further series of experiments; and although he has not had time or opportunity to deduce, in a thorough and final manner, the laws which govern creep, he has come to certain conclusions which, as current literature on the subject almost wholly demonstrates that the cause of creep is not understood, he thinks it desirable to put on record.

The results of the further experiments, which were made not only with pine laths, but also with flat iron bars on side and on edge, and with a strip of India rubber, are given in a table, and the conditions under which they were made are explained in detail.

The broad conclusions at which the author arrived were:

(1) Creep of rails is due primarily to deformation of the rail as the wheel passes over it. It may be likened to the movement of dough when rolled under a rolling pin.

(2) The more violent the deformation, the greater the creep. That is to say, that creep is increased by (a) increasing the wheel load; (b) diminishing the rigidity of the rail, by either reducing its section or using a weaker material.

He then sets out in detail the evidence in support of these conclusions, and proceeds to discuss the influences of various factors as follows:

Weight of Wheel.—This appears to be the most powerful factor affecting the amount of creep.

Rigidity of Lath.—In every case the creep was much greater with the lath on the flat than with the same lath on edge.

Continuous versus Intermittent Support.—With the pine lath, the creep was always greater—from twice to four times—when the lath was supported on sleepers resting on the naked bench. The effect was heightened when the lath was on the flat as compared with on edge, which again bears out the theory that creep is an effect of deformation in the rail.

Yielding of the Support.—From the experiments with the pine lath the general conclusion is that interposing a strip of rubber between the bench and the lath made little difference, even reducing the creep, if anything (except in one case with a heavy wheel on a lath on the flat). It would appear that with a light wheel load and a rigid rail the yield of the roadbed has little effect, and that little rather negative than positive; but that with a heavy wheel load on a flexible rail the creep is decidedly increased by a yielding roadbed.

The author suspects that the amount of creep produced depends on the violence of the distortion the rail suffers, rather than its total quantity.

The author then advances a theory of the occurrence of creep in a rail under a rolling load, and finally sums up what is known about creep.

Creep, he concludes, is caused primarily by deformations of the rails under the rolling loads, assisted by temperature changes, which cause fish-joints to slip and lessen the resistance. Where track is on a yielding roadbed, creep is intensified, especially under heavy wheel loads. It is also accentuated by braking, in places where regular stops are made.

Creep is greater down hill than up hill, but is by no means absent on the latter.

It is usually asserted to be worse in hot weather than in cold. The author thinks it would be more cor-

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*Abstracts of two papers read at the ordinary meeting of the Institution of Civil Engineers.

rect to state that the effects of creep are more troublesome in hot weather. It, however, comes to much the same thing from the practical permanent way man's point of view. What probably happens is that the powerful expansion of the rails overcomes the resistance of the fish-plates, and allows the creep, which before was kept within bounds by the resistances, to take effect and become troublesome at certain points.

Direction of Creep.—Creep is always with the traffic. On single lines there is normally no trouble with creep. But if there is a great preponderance of traffic in one direction, more or less creep takes place in that direction.

Remedies.—Creep can be resisted more or less completely by putting in enough anchorage or resistance.

The author describes several devices for this purpose, including one of his own design which is in use on the Buenos Aires and Pacific Railway.

Amount of Creep.—It is easy to reduce creep to a small amount by putting in anchors, but it is not easy to suppress it entirely on double lines under modern conditions.

Differential Creep.—In double track the outer rails (the rails near the edge of the ballast) run more than the inner. This differential creep is the most troublesome and expensive of all. In laying double track the author's practice is to set the outer rail back 2 inches, and not until it has crept forward "into square" are the rail anchors applied.

Bad Effects of Creep.—There would be little harm in creep if all the track were "open track," and both rails "ran" equally. Where it compels preventive measures is at connections with other lines, junctions, sidings, crossovers, level crossings with other lines (railway or tramway), swing bridges, etc. The only practical way to anchor track is over long stretches and through numerous sleepers.

Design of Structures.—Many railway structures are affected by creep, and their design should take it into consideration. This requires special emphasis in the drawing office.

Mechanism of the Hardening of Carbon Steels

The rate of cooling, in an inert atmosphere, of a steel wire, after heating to a red heat by an electric current, varies largely with the nature of the gas. Hydrogen generally produces hardening, while in nitrogen, annealing usually occurs, and with a mixture of the two gases, a whole range of intermediate conditions can be obtained. By means of a registering differential dilatometer, the curve, which is traced photographically, of the thermal dilation during cooling records transformations in the metal with great sensitiveness, and the method is almost independent of the rate of cooling. In the curve which is traced, the ordinate gives the difference of expansion of the wire which is being studied and a standard wire of "baros" alloy which is maintained at the same temperature. The temperature is recorded by the expansion of the standard which traverses the abscissa axis of the curve. The two wires of 0.23 mm. diameter are held close together in a gas-tight case and connected with an adjustable electric circuit by which the current through the two filaments is regulated so as to give equality of temperature, which is judged optically. After any particular thermal treatment a microscopical and mechanical examination is made of the metal. With a given steel and identical conditions of cooling, the nature of the transformation was found to depend on the temperature reached during the heating. When the initial temperature of the metal was gradually raised, the transformation corresponding to the formation of pearlite of minimum hardness, which normally occurs at 600°-650° C., is gradually lowered. Above a certain temperature of initial heating θ_s, the transformation occurs in two stages, one reverting to a temperature of 200°-300° C. With further increase of temperature the proportion which reverts increases, and at a certain temperature, θ_i, reversion is complete. On increasing the rate of cooling, the temperatures, θ_s and θ_i, are rapidly lowered, approach each other, and finally coincide. The transformation which reverts to the lower temperature corresponds to the formation of martensite, i.e., to the condition of maximum hardness. The phenomena are more complex in the cases in which the transformation occurs in two stages, but it was found possible to obtain products which microscopic examination showed to contain both troostite and martensite. The speed of cooling with very fine wires is probably greater than can be obtained with more massive samples; in the latter case, the internal pressure produced during the contraction tends to oppose the passage from the γ to the α state.—*Note in the Journal of Society of Chemical Industry on an article by P. Chevenard in Comptes rend.*

Small Castings from Alloys and Scrap Metals*
By Walter J. May

IF you want castings for machining you will have to treat the metal chemically, and as no one flux will give all-round results, you will have to experiment with different materials. It is desirable to have some 20-pound plumbago crucibles, tongs, and scales and weights. Either 12½-pounds or 14-pounds, of metal should be dealt with each time, according to whether you are dealing with percentages or actual weights, 12½-pounds being one-eighth of 100 pounds, and 14 pounds one-eighth of 1 cwt., and one-eighth of 1 pound being 2 ounces, these are all easily workable determinations.

So far as the chemicals used are concerned, these in ordinary times are readily obtainable at moderate prices; but now some will cost four or five times the pre-war especially when purchased in small lots for experimental work; but such things as salt (sodium chloride), carbonate of soda, which is sold crystallized as washing soda, and in the dry state in packets under fancy names, such as "bleaching soda," sodium sulphate sold as "Glauber's salts," magnesium chloride sold as "Epsom salts," and some others can be purchased more cheaply at oilshops than at the ordinary retail chemist shop, while, of course, sal-ammoniac (ammonium chloride) will be obtained at oilshops supplying battery salts.

In most cases wood charcoal has to be used because its action is to reduce oxides and prevent further oxidization, while it is desirable that the effect shall be prolonged during the melting period. For this reason charcoal should be broken or crushed to pass about a ⅜-inch square-meshed sieve, but should be free from dust; and probably in many cases this will not be easy to get. Where it cannot be got, the better plan is to roughly crush the large charcoal and use the fine stuff which is produced in the operation for blacking after it is sifted out through a fine sieve. Powdered charcoal soon goes to ash on the surface of molten metal, and it then becomes inert.

In dealing with aluminium and its zinc alloys, as the scrap ingots are supplied they are—when melted—full of particles of oxide or dirt, and while usually these do not show on the skin of the casting, when the skin is taken off they show up very badly, and where a screw thread has to be put on stripping or breaking is likely, and, in any case, rejection will follow. To get over the trouble zinc chloride up to about three ounces per 100 pounds of metal is used, considerable care in regard to temperatures being necessary. A handful of charcoal is placed in the bottom of the crucible, and on this the metal, and as it melts down more is added until the crucible is sufficiently full. As soon as the metal under the oxide is of a wine color the zinc chloride, wrapped in a piece of thin paper, is pressed down to as near the bottom of the metal as possible, and as soon as liberated from the paper well stirred into the metal. The crucible is allowed to rest until the reaction ceases, and is then lifted from the fire, skimmed carefully into water to enable the recovery of any metal which the skimmings contain, and the metal at once poured into molds, which should be waiting. The metal is ready for pouring at from 850° to 1,300° F., according to content, while the zinc chloride melts and dissociates at about 504° F., some slight variation possibly arising owing to differences of content; but in any case this salt gives complete association with the metal and causes the removal of dirt unless negatived by overheating the bath of metal. All these aluminium metals and alloys should be emptied from the crucibles each time of melting, or trouble will be caused.

"Brass" covers a lot of the CuZn alloys. lead and tin often being purposely present in small quantities, while iron and sulphur are also usually unintentionally present to some extent. Aluminium is also present in a good many cases, the percentage being small usually; but the effect is pronounced in making the metal flow freely and in the production of a good skin. Where goods have to be plated, aluminium cannot be used, as the presence of this metal is not an advantage, but for some purposes up to quite 0.25 per cent can be added with good effect. In melting down scrap ingot for castings which have not to be machined, but which must have a good, bright skin, a large handful of coarse charcoal is placed in the bottom of the crucible and on this comes the metal, more charcoal being subsequently added if found necessary when adding fresh metal. When the crucible is full of molten metal it should be lifted from the fire and skimmed, after which the allotted amount of aluminium should be added and well stirred in, and then, when steady, the metal should be again skimmed and at once poured into the molds. For machining the metal is melted with charcoal as before, and while the crucible is still in the fire from four ounces to eight ounces of coarse salt wrapped in thin paper, is forced to the bottom of the crucible of metal, and when the fumes commence to rise the metal is vigorously stirred. When the reaction ceases, if aluminium is to be added, this is stirred

* The *English Mechanic*

in, and after the metal has steadied, the crucible is lifted from the fire and at once skimmed and poured, no further stirring being permissible. The exact quantity of salt used does not much matter so long as it is sufficient but it is necessary that it shall attack all parts of the metal, so that the more or less pasty portions are released together with the entangled oxide or dirt.

With gunmetal scrap there should be little trouble, this, as a rule, coming sound when melted with the charcoal previously advised; but in some cases a mixture of equal parts of ground charcoal and phosphate of soda at the rate of from two ounces to four ounces per one hundred weight of metals hould be very effective in securing clean metal which will turn up bright and free from specks. The use of a small amount of phosphortin should also have the same effect where there is no zinc in the alloy; but often in the presence of zinc phosphorus causes minute gas-holes a short distance under the skin of the castings, these not being found until machining is done, as the skin appears really good for all purposes. Provided the scrap and swarf are properly melted before pouring into ingots, bronzes of all kinds should be clean enough for use, and if remelted with charcoal as advised for brass, clean castings should be produced. If, however, a chloride flux is used, probably it will be found that salammoniac will give the best results, about two ounces per 100 pounds of molten metal being used.

Phosphor-bronze should by itself melt quite clean and need no addition, although the phosphorus content will be doubtful in the remelted scrap ingots; but where the original scrap was high in phosphorus—from one per cent to three per cent P at times being specified—the scrap should hold enough for most practical purposes, hardness being secured by adding tin.

Lead holding small amounts of zinc should be treated with sulphur to bring off the zinc as sulphate of zinc, and after this has been done, the lead should be melted over ground chalk to remove sulfur, or calcium chloride can be used for this purpose, although molten lead will not really melt this chloride, it having a melting-point of about 1,330° F. Remelted scrap lead, or lead and tin alloys, are not largely used for work requiring clean metals, however, and except for solder even a small percentage of zinc does not much matter.

White bearing-metals, when reduced from scrap, offer a difficult problem, because not only do they hold iron, but different brands have different contents, the result of the haphazard melting of mixed scrap being to produce a metal which may have no value as an anti-friction alloy whatever. Of course, if scrap metal of one brand—Magnolia, for instance—is run down carefully there should not be sufficient change in content to do more than make it rather less efficient than the new alloy, but there will be specks of iron held in the body of the metal which will not float off, and which cannot be removed in ordinary working, this small amount of iron reducing the efficiency of the alloy for its intended purpose.

Where scrap copper is dealt with, iron alloyed with the metal up to a certain percentage must remain so far as ordinary foundry practice is concerned, but pieces of iron not alloyed will float off with the slag, although copper and iron melt at about the same temperature. Otherwise, copper is best treated by the boronising process, this bringing off the bulk of the impurities. This boronising is done by adding from 0.08 per cent to 0.10 per cent of boron suboxide to the molten metal, well stirring it in, and as soon as the reaction ceases skimming and pouring the metal. Copper has a great antipathy to boron, and ejects it as quickly as possible, during the ejection the boron bringing off entangled oxides and other matters, the metal then pouring soundly and without an excess of suspended foreign matters, the copper being good enough for alloying, if not for use as a single metal.

All scrap metals, before being melted to run into ingot form, should have grease—if present—burnt off and the friable scrap run through a magneting machine of good make, some form of electro-magnetic separator being preferable to the usual form of permanent horseshoe magnet separator in common use, which is often too weak to be effective. Magneting, to be effective, must remove iron from the non-magnetic metals—and incidentally there are other magnetic metals than iron which it is desirable to take out from brasses, etc.— or otherwise trouble will arise, because even a small percentage of iron will alter the working qualities of metals to a great extent, even 0.25 per cent of iron being a disadvantage where aluminium is used in the alloy, especially as iron when free from carbon—mild steel, for instance—freely alloys with metals which will not alloy with ordinary foundry iron to any appreciable extent. The importance of effective magneting will thus readily be seen.

Where ingotted scrap is concerned nothing but clean-

ing the metal can be effected, but in using up loose scrap by adopting a proper system of sorting and cleaning very little trouble need occur, overheating being perhaps the greatest difficulty. The best method of melting is to produce a bath of molten metal by running down some of the heavier scrap, and then gradually adding the fine stuff as each lot melts. By careful manipulation of the heat, and by maintaining a reducing atmosphere in the crucibles by the use of charcoal, really clean metal should be produced, but necessarily a good melter must be in charge.

Iron castings made largely from scrap often give trouble, blowholes being the principal cause. The remedy is not easy. Generally speaking, a moderate amount of limestone in some form should be used in the cupola. The cupola being purely a melting furnace, it is desirable that the metal and fuel charged be as free from objectionable impurities as possible, and that the metal be melted as quickly as possible with an ample, yet "soft" blast, volume of air being necessary, but high pressure injurious. With clean iron and clean coke there should be clean metal and sound and good castings; but where scrap metal is largely used the metal poured is often undesirable for good work. Iron will pick up impurities in the cupola, but except for the filtration through the layer of slag over the already molten metal, very little purification can take place, and in this way the matter of treating the metal has to be dealt with principally in the ladle. Usually the chief cause of blowholes is the presence of oxides in the metal, and very often if a handful of crushed—not powdered—charcoal is thrown into the ladle just before tapping this is sufficient; but, in addition, a few ounces of powdered fluorspar stirred into the metal will give freedom from holes if the ladle stands until the metal steadies after the reaction set up, and the surface of the metal is then carefully skimmed. Another plan is to use a small amount of crushed ferro-silicon in the ladle with or without the charcoal, the amount varying with the percentage of silicon; but the metal should not hold more than about 2.5 per cent silicon when poured. Ferro-aluminium or ferro-manganese, broken small, and used at the rate of about six ounces per one hundredweight of molten metal, placed in the ladle before tapping also proves useful in some cases; but really the content of the iron governs what shall be used, there often being very wide differences in what the ladle actually holds. In some cases carbonate of soda will be found useful if stirred into the metal in small lots of, say, two ounces to four ounces per one hundredweight. Where iron comes hard the moderate use of ferro-silicon, or in some cases ferro-phosphorus, will tend to soften it, especially where charcoal is used in addition; but too much softening must not be expected, it being, as a rule, necessary to use soft iron to obtain soft castings. In all cases the metal should be brought down hot and fluid in melting, and quick melting with low air pressure is more useful for this than air delivered at high pressure.

In the molding the upper parts of iron molds should be well vented to give free escape to air and gases which might otherwise be entrapped in the metal, and it is always a safe precaution to lightly face the molds with carbon in some form to prevent actual contact between the iron and the sand of which the mold is made, as in some cases the mold substance will give off gases that will be entrapped by the metal, the composition of some molding sands being such that they will not produce sound castings. This, of course, has to be looked to as well as the metal and melting; but with scrap-metal work it is usually the metal which causes trouble. Iron coated with zinc or lead, or which is charged with paint, is likely to produce unsound castings, and the presence of zinc, lead, copper, and one or two other metals will not be an advantage, for. which reason scrap iron should be carefully sorted and examined before being melted, anything doubtful being thrown out for use in work in which soundness is not essential.

At the present time with all metals and alloys it is necessary to keep an open mind as to the use of "fluxes," as they are called, because only the veriest rubbish is in many cases obtainable. Not only does the ingot stuff cast badly, but the waste is excessive, one hundred-weight of brass ingot as now supplied only giving about ninety-five pounds of run metal, the rest being mere oxide and dirt on the surface and pieces of iron bedded under the surface.

Conservatism In England

BEFORE English officials will order a plant they insist on seeing one of the same size in actual operation. A case is cited of Americans, years ago, ordering a 25,000 k. w. set in England on the knowledge of what similar machines of a much smaller size were capable, and now American manufacturers are preparing to produce sets of 75,000 k. w., whereas England has not yet put a set of 25,000 k. w. into operation.
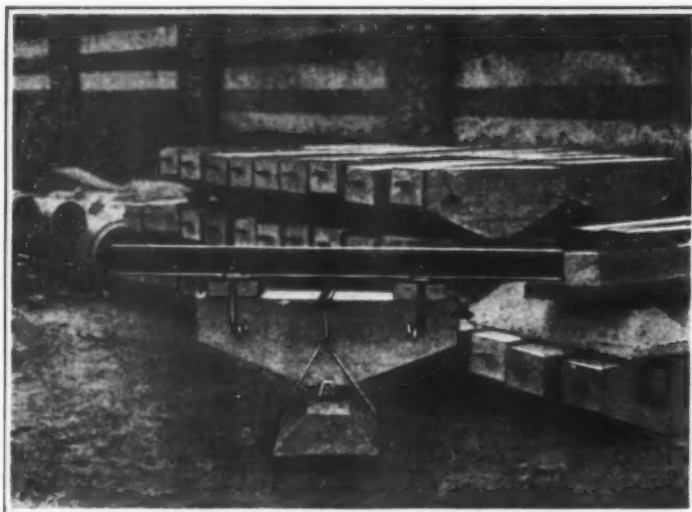
Fig. 1. Concrete longtitudinal sleepers

Fig. 2. Railway line laid on the new sleeper

Longtitudinal Sleepers for Railways and Tramways*

A NEW method of constructing railway and tramway lines has been introduced by Signor Olindo Valeri, of Asti, Italy, consisting in providing a series of inter-linked sleepers of reinforced concrete, arranged length-wise beneath either rail of the line, as shown in Fig 3. The main feature of these longitudinal sleepers is that they are capable of a rocking motion, since they rest on a pedestal with the center line of their base only. This rocking motion permits a certain resiliency of the rail. Interposed between the sleepers and the rails are blocks or cushions of hard wood, which form the real supports of the rails, these supports being spaced about the same distance apart as are the cross sleepers generally used.

Experiments with Signor Valeri's sleepers began some months ago on the line between Asti and Alta-villa, of the Società Astese Monferrina di Tramvie e Ferrovie of Asti.

Figs. 3, 4 and 5 give details of the new construction, while Fig. 2 shows a piece of line, laid on this principle, before the ballast has been applied. In the drawings R, R indicates the rail, C, C the ferro-concrete sleeper, Q is the wooden block or cushion inter-posed between sleeper and rail, G a bolt for anchoring the rail to the sleeper, L the link be-tween successive sleepers, and B, B the base or pedestal for each sleeper. The rails are held to gauge by means of a number of tie-rods T, of which, as a rule, one is provided for each couple of oppositely arranged sleepers. These gauge bars engage the rail by aid of clamps, which grip the base of the rail, so that it is not necessary to drill the rails.

Two sleepers constructed in accordance with the new system proposed by the writer were submitted, after almost four months' seasoning, to a hydraulic pressure test at the Laboratory of the Turin Technical High School. The first fissures could be observed when the pressure had reached about 12,000 kilos., and the sleeper broke under a pressure of 18,000 kilos., viz., under a pressure of about 9,000 kilos., nearly 9 tons, on each of the two supports.

Signor Olindo Valeri points out, in connection with this test, that a sleeper which is submitted by itself to the action of a hydraulic press is in a much more unfavorable position than a sleeper actually in service and forming part of a line of railway. A line of rails, and particularly such rigid rails as are those of large weight per unit of length, forms a continuous beam laid on an indefinite number of supports, and partly fastened, or at least not completely free, to move. Moreover, the sleeper reacts against dynamic shocks, both by reason of its ability to swing and the links between the suc-cessive sleepers, as well through the natural reaction of the ground, and he assumes that the utmost stress which a sleeper has to resist when a train is passing over the line is more or less equal to the normal load on a wheel, which, on the line

*From The Engineer.

where these sleepers are being tested, is about 7 tons. The pressure will have its maximum value when the wheel bears on the rail at the point which corresponds to the center of the sleeper, when each of the supports will bear a weight of 3.5 tons. As has been said, the sleeper broke under a pressure of about 9 tons on each support, which ought to provide a wide margin of safety. In many cases the quantity of additional material required to increase that margin would be small, since a slight heightening of the sleeper with concrete only will be sufficient for the purpose.

Another claim made for the system is that it is pos-sible, not only to obtain a perfectly level track, but, as a rule, also to maintain it unaltered. Should the level of the track have to be rectified, neither the chair nor the sleeper need be removed, as the requisite adjust-ment may be obtained by suitably altering the height of the wooden cushions between sleeper and rail. The rail is prevented from canting by the bolts employed for anchoring the rail to the sleepers, also by the action of the tie rods, and because they are connected to the
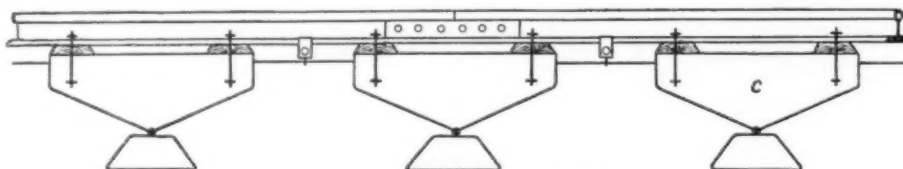
two ends of the neighboring sleepers.

Briefly, the objects which were kept in view when the system was evolved were to attain (a) uniform elasticity; (b) a greater perfection in, and a greater maintenance of, the level of the line; (c) a greater ex-actness and a better maintenance of the gauge; (d) a resistance to canting at least equal to that possessed by lines as at present constructed; and (e) less creeping of the rails. The material required for the construc-tion with the new longitudinal sleepers of one meter track for a big railway consists of about 0.125 cubic meters of ordinary ballast, and about 47 kilos. of reinforcement.

Fig. 3. Arrangement of concrete longtitudinal sleeper

The Housing Problem in England

PORT SUNLIGHT is the materialized expression of the ideals of Sir William Lever, carried out in the generous spirit of its founder, and its success gives him the right to speak authoritatively on the present question of the shortage of cottages, a problem which has grown infinitely more acute since the outbreak of war. The
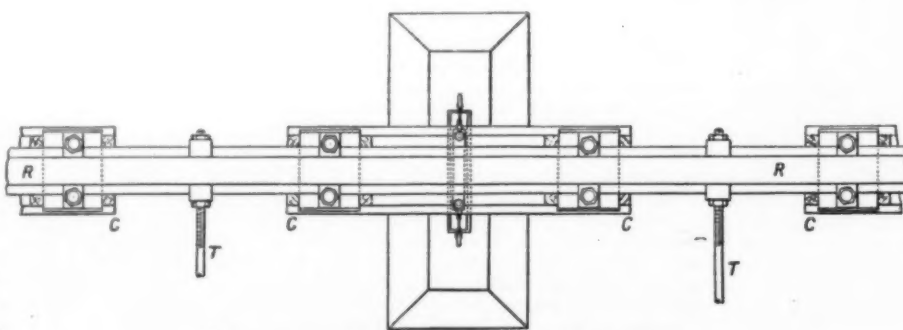
underlying principles in the laying out of the estate for the benefit of the operatives in his own soap manu-factory are that man being individual as well as gre-garious needs separate dwellings to live in, instead of tenement houses in which he is herded like cattle and where, experience suggests, he rapidly degenerates; that the dwellings must satisfy the wants of the tenant even when these requirements are not quite in accord with the views of the builder, and that a little ground allotted to each cottage will be turned to profit by the tenant.

In Sir William Lever's opinion the matter admits of no tinkering, and some drastic step will have to be taken to insure, not only adequate building in the present, but a continuous supply for the future. He combats the scheme that has been brought forward (for the Govern-ment to take in hand all these building operations) on two grounds: (1) that it would drive the private builder out of the field through his inability to compete with the Government. Thus, if the Government were unpre-pared to maintain their building operations for an in-definite period, building would languish after the Government had ceased to deal with the question; and (2) that the Government is unsuited to the work, owing to its ignorance of local conditions. In proof of this statement he instances a case of a London architect erecting in Yorkshire a house eminently suitable for Surrey, but not even rainproof in the stormy climate of the former county, and also the mistakes of Government in laying out an estate at Woolwich, where the roads and buildings were so planned that the children had to go a mile and a half to the nearest school, and the only con-nection with the main roads was at the two ends of the estate. As the Government architect could not de-viate from the order to build 1,400 cottages, he therefore could not allow space for the necessary playgrounds, schools, etc. Sir William Lever's remedy is for every municipality to purchase suitable land in the suburbs of its own town and give it free to the builders for the erection of cottages at such a rent as will enable the tenants to pay their fares to their places of work and still live cheaper than they ever could in the slums. He says:

"As to the objection that it may be unjust to the remaining portion of the population, the rates payable on the property built on this free land would not only pay for the land which was being given, but, in ad-dition, result in a profit to the municipality adopting this policy." Neither is this giv-ing of land as revolutionary as it seems, for it has a precedent in the principle of the free educa-tion of the people—entirely State-supported—the utility of which is rendered abortive by compelling the children to live in conditions that "absolutely neutralize all the benefits de-rived from education." To sum up in his own words: "* * * Dear land is the chief cause of high rents for cottage houses. The cheapening of the land will be the most powerful factor in reducing cottage rentals."

—Science Progress.

Fig. 4. Plan view of the new method of construction

Nutrition of Oysters*
By Phillip H. Mitchell

MORE and more the difficulties of producing well-nourished oysters for market are prone to increase. The continued increment of population along the seaboard causes ever greater pollution of those waters especially suitable for the "fattening" of oysters. Not only does the fresher water of bays and inlets increase the meats of oysters by causing osmosis of water into the tissues, but the actual food for oyster fattening in the true sense tends to be more abundant in such waters. Modern sanitary limitations to oyster culture have therefore made it important to the industry that further information concerning food for oysters and the conditions under which they can be made to yield larger amounts of marketable meat be obtained by investigation. The present paper is one step in that direction.

Chemical analysis of oyster meats would seem to offer the only reliable method of estimating the food value of oysters, since the size and weight of either the entire oyster or the "shucked" meats depend so much on the relative amounts of inorganic matter present as shell and sea salts and on the relative amount of water present that the food value is not truly shown. Estimations of glycogen in the oyster promised an especially fruitful method of studying changes in its nutritive condition, because this substance may constitute the most abundant single constituent when present to the extent of 20 or 25 per cent. of the dried meats and because it is subject to very great and comparatively rapid fluctuations in amount. The actual variations in glycogen must be distinguished, of course, from the percentage changes caused by differences in water and salt content of the oyster. It was necessary then to calculate glycogen for the moisture and ash-free constituents of the entire shell contents of the specimens used. Glycogen estimations were made by the well-known Pfluger method. Ash determinations were difficult to make because of the slowness with which some of the organic matter burned and the tendency of some of the inorganic matter to volatilize. The use of porcelain crucibles kept at low red heat during about two hours in a muffle furnace was found to be satisfactory.

SEASONAL VARIATIONS IN GLYCOGEN CONTENT OF OYSTERS

The results indicate a seasonal variation in the glycogen content of oysters. In the specimens observed it was very low during the early summer. This may have been due to spawning or to the fact that the oysters used early in July had been recently transplanted to shallow water, where they would be exposed at very low tides. At any rate the figures show that glycogen may become greatly depleted. It steadily increases, however, during the summer and fall, until just before cold weather it amounts to 20 per cent. or more of the dried weight. Lower figures were obtained in the winter.

These observations were not primarily undertaken for the purpose of studying seasonal variations in the glycogen content of oysters under natural conditions.

That glycogen would be used up during warm weather might be expected from the author's experiments on the oxygen requirements of oysters,[1] which showed the direct relationship between temperature and oxidation. It is well known that increased oxidation in animals involves the utilization of some of the stored-up glycogen.[2] Further observations on the glycogen variations during winter months would furnish chemical evidence as to whether oysters hibernate or continue to feed during the cold weather. These data, so far as they go, favor the hibernation idea.

THE FORMATION OF GLYCOGEN FROM DEXTROSE

The formation of glycogen from dextrose was tested out by putting oysters into large, shallow glass dishes containing sea water of known specific gravity and known amounts (usually 0.25 per cent.), of either pure dextrose or crude glucose. It was found that larger

[1] Mitchell: Oxygen requirements of shellfish. Bulletin United States Bureau of Fisheries, Vol. XXXII, 1912, p. 209.
[2] Lusk: Elements of the science of nutrition. 1909.

amounts of sugar were toxic. Experiments employing 1 per cent. and even some with 0.5 per cent. of dextrose had to be discarded because of high mortality among the oysters. The toxicity of an unphysiological abundance of dextrose is in accord with common observations on higher animals. Oxygen was constantly furnished throughout the experiment by bubbling air from an aspirator bottle through glass tubes reaching to the bottom of the dish. At the end of a period, varying from two to five days, the entire shell contents of the oyster were dried down and analyzed. Analyses, for comparison and control, were made on oysters taken from the same source as those used for feeding with sugar, but analyzed at the beginning of the experiment; and also analyses of oysters from the same lot kept meanwhile in aerated sea water containing no sugar. In one experiment a further control consisted in the analyses of oysters having the same origin as the others, but kept during the time of the experiment in a wire cage suspended in the water near the Government
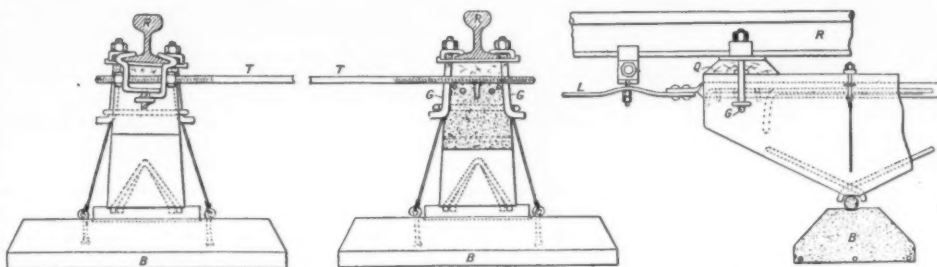

Fig. 5 Details of construction with the concrete sleeper

docks at Woods Hole harbor. Here with garbage and animal and plant life in very great abundance, feeding conditions were about as rich as could be obtained. The results of the experiments show clearly that glycogen may be formed in the oyster from dextrose, while one experiment shows that even richest feeding in excellent normal conditions with abundant tide flow did not cause as much glycogen formation as that obtained by treatment during the same time with a 0.25 per cent. dextrose solution and under somewhat adverse conditions at that. The oysters were crowded into a dish in water that was not changed throughout the time of the experiment. It apparently makes no difference whether the oysters at the start contain much or little glycogen. The amount formed in any case is about the same for two or three days' treatment with dextrose, i.e., 1.5 to 2.5 grams of glycogen to every 100 grams of organic matter. The numbers of oysters used in these experiments would seem to exclude the possibility of accounting for variations by mere individual differences, especially since the dried shell contents of all oysters used in any one experiment were very thoroughly ground and mixed before analysis.

The storage of glycogen can not continue indefinitely under the adverse conditions used in these experiments. In one case oysters kept in aerated but unchanged sea water, containing 0.25 per cent. of dextrose, during five days, yielded glycogen to the amount of 11.12 per cent. of the ash-free solids, but the corresponding figure for some of the same oysters analyzed at the beginning of the experiment was 13.57 per cent.

The optimum concentration of dextrose for glycogen formation was found to be about 0.25 per cent. It was found that 1 per cent. of dextrose was toxic. Oysters exposed to it showed inability to close their shells normally after 24 hours' exposure and rapidly died off in about two or three days. If removed from the sugar-containing water soon after signs of distress appeared, the oysters recovered their normal behavior in the course of a few days' immersion in running sea water.

The effect of different specific gravities of the sea water containing dextrose on glycogen formation was studied. Fresh or nearly fresh water did not permit glycogen formation. The evidence points to the fact that any change in the salt concentration at the time oysters are transferred from ordinary sea water to dextrose-containing water is a deterrent to maximum glycogen formation.

An attempt to study the effect of the varying concentrations of specific inorganic salts was made. The immediate object was to find the effect on glycogen storage of adding phosphates to sugar-containing water whose density was low enough to check the glycogen process. The experiments show a tendency of phosphates to interfere with glycogen storage.

The possibility of the formation of glycogen from dextrose by oyster meats separated from the shells was tested, because in the present-day practice of the oyster industry the meats, before packed for shipment, are washed freely with tap water during periods vary-

ing in different establishments from a few minutes to several hours. If the glycogen increment, then, could be obtained during this process by addition of glucose to the wash water, an obvious economy would be attained. Only one such experiment is reported, as time and opportunity for conducting others have not yet been found. The result of this was entirely negative. This might be expected physiologically. With the circulation destroyed, death coming on in the tissues, and metabolism coming to a stop, it is hardly likely that a synthetic process like glycogen formation would occur with sufficient activity to overbalance the hydrolytic process of glycogenolysis known to occur in various dying animal tissues.

The failure of oysters to form glycogen from dextrin was observed in two experiments. This possibility was tested because only crude commercial glucose, which always contains dextrin, could be used economically in practical work with oysters. Purified dextrin was used.

NUTRITION BY SEAWEEDS AND PROTOZOA

Algæ and other microscopic life constitute the food of oysters.[3] In these experiments oysters were fed in glass jars of aerated water with sea lettuce (Ulva lactuca) chopped into fine fragments and added fresh at intervals of one or two days. It was found that the material had to be in fresh condition, because if it darkened and decomposed, or if the water in the containers was not changed frequently enough the oysters would die. That this material was ingested was shown by repeated microscopic observations of the stomach contents of oysters so fed. All the sea water used was carefully filtered through several thicknesses of fine filter paper so that, as shown by subsequent microscopic examination, it was freed from algæ. It is true that some algæ clung to the sea lettuce, and Protozoa and bacteria from the same source were also present in the preparation. The multiplication of these organisms provided, therefore, a part of the nutrition for the oysters. Several experiments were started, but only one was successfully continued long enough to be of value. It indicates that the seaweed fragments contributed to the nourishment of the oyster.

Whether accumulations of seaweed on oyster beds may cause the death of oysters is a question of practical interest to oystermen. Gorham[4] observed the death of oysters on beds where seaweeds in which Ulva predominated had lodged in masses sufficient to cause putrefaction. In his opinion the seaweed was the cause of death.

The following experiments on this point were undertaken: Wooden boxes about 30 inches square and 3 inches deep were filled with sand and gravel, and 25 oysters were laid on top of the gravel in each box. A basket of galvanized wire netting was made so as to fit over the top of each box with a space of 3 or 4 inches above the oysters. Two such boxes, one with the wire basket loosely filled with seaweeds and the other without them, were then anchored together in each of several locations on the shores of Narragansett Bay in waters suitable for oyster culture. The seaweeds used were mostly Ulva with some eelgrass. In one case Ulva alone was used. Four such experiments were carried out. In two of them the oysters were taken up for observation after 29 days, in one after 25 days, and in one after 14 days. In every case the oysters under seaweeds were found to be dead and badly decomposed, with the meats running out of the shell. Of the 100 oysters so treated only 7 were found alive and 6 of these had discolored meats showing signs of incipient putrefaction. All the control oysters showed no pathological conditions or signs of decay, and from the new shell formation during the progress of the experiment, showed abundant evidence of flourishing growth. It would seem, then, that although seaweed may serve as food for oysters, accumulations of it in places where the tide does not keep it sufficiently in motion must be guarded against in oyster culture.

The nutrition of oysters by Protozoa was also investigated. Rich cultures of various Protozoa were added daily to a dish of filtered, aerated sea water containing oysters. As algæ were excluded from this experiment, only Protozoa and bacteria, but with Protozoa predominating, served as food for the oysters. They appeared after 17 days, when the experiment was ended, to be in a nutritive condition comparable to the

[3] Brooks, William K.: The Oyster. 225 p., 1905. Baltimore.
[4] Gorham: Annual Report, Rhode Island Shellfish Commission, 1904.

oysters from the same source examined before the experiment.

An attempt was made to follow the nutritive condition of the experimental oyster by determinations of nitrogen in the dried tissues. From the results of 20 analyses no definite conclusions could be drawn. In the various artificial feedings, changes in the nitrogen content of the tissues were observed, but they were always small and in most cases merely percentage changes attributable to the altered proportions of salts and glycogen, rather than to a change in the actual amount of protein present.

SUMMARY

A summary of the results of this work follows:

1. Evidence was obtained of a seasonal variation in the glycogen content of oysters. A depletion occurs in the warm weather but is followed by a storing-up process in the latter part of the summer and in the fall. Glycogen seems to decrease during the coldest weather. This favors the idea of hibernation. The results on seasonal variation agree with the results of Milroy.

2. Glycogen may be formed in the oysters from dextrose. Fat storage may occur simultaneously.

3. The optimum conditions for this process are: (a) Duration of dextrose feeding two to three days; (b) concentration of dextrose equal to about 0.25 per cent; and (c) water density not greatly different from that in which the oysters have previously been.

4. Excess of sodium phosphate in the medium may check glycogen formation from sugar.

5. Formation of glycogen from dextrin was not obtained.

6. Failure of glycogen formation from sugar by oysters taken from the shells was observed.

7. Evidence that Protozoa and fragments of seaweed (*Ulva lactuca*) may serve as food for oysters is given.

8. Decaying seaweeds lodged above oysters that are under otherwise good growing conditions may cause their death.

Beyond the Microscope
By F. Rowlinson

THE mind of man can conceive, although it cannot perhaps imagine, all degrees of magnitude from the infinitely large to the infinitely small. From the revelations of astral-chemistry man can determine the constitution of stars so far away that their light takes centuries to reach us; by the methods of physical chemistry he can investigate and even weigh the smallest portions of matter. And the latter investigations reveal wonderful and yet more wonderful microcosms than the systems the astronomer has yet discovered.

It has long been assumed, even by the ancients, that the ultimate constitution of matter is granular. Systematic science is based upon this assumption, and these grains of matter have received the name of "molecules"—literally, "little masses." Now the practical limit of magnification of the ordinary microscope is about 3,000 diameters, and it has been found that the molecules of matter are very much smaller indeed than the smallest visible object under the microscope. So for many years we were forced to take the molecular structure "on trust," as it were, for there was no method of demonstrating it. But now "we are face to face with this extraordinary situation; the molecule has ceased to be an abstraction of theory; it has become a visible and concrete reality, for not only can we see it, but we can also manipulate it by means of heat, and electricity, and the air pump." (Fournier d'Albe.)

The molecular particles which constitute matter cannot be seen by an ordinary microscope. They may, however, be rendered perceptible to the eye by another means. It is a matter of every-day observance that the motes in a beam of sunlight are normally quite invisible; but as soon as a powerful ray of light falls on them they become quite distinct. The myriads of particles in the air, however, are monstrous as compared with those we are considering. If the latter be viewed by a lateral beam of light, their very smallness enables them to scatter it, and their presence is immediately made visible under a powerful magnification, just as the motes in the sunlight are by a similar phenomenon.

The first steps in the demonstration of the existence of molecules were made by Brown in 1826. He observed that if very small particles of any solid be suspended in water, they are in constant motion to and fro, hither and thither, like gnats in the summer air. Such small particles as are found in colloidal "solutions" (which resemble true solutions, but differ in properties from them) are also found to exhibit this property of motion when in suspension. The phenomenon, which is named the "Brownian movement," after its dis-

coverer, is independent of the composition of the suspended matter—gamboge, the spores of the lycopodium, colloidal particles of metals, etc., all exhibit it. The only condition is that the particles should not be too large.

Whence comes this never-ceasing motion? The answer is that it is due to movement amongst the molecules of the water itself, and the granules in suspension are pushed about by the aqueous molecules surrounding them. The movements of gamboge, for instance, seem exceedingly rapid and erratic, while those of the colloidal particles seen under the ultramicroscope are even more active. Notwithstanding, they are extremely sluggish as compared with the inconceivably rapid motion of the molecules of water. We can picture them, moving in space with great velocity, colliding, rebounding, darting hither and thither, changing their courses many millions of times per second. And they buffet the suspended particle about in a feeble imitation of their own swift motion.

From suitable observations upon such suspended particles the requisite data for the calculation of the size of the molecule may be calculated. To enable the reader to grasp the magnitude of the molecules and the rapidity with which they move, the following figures are given. Forty million molecules, touching each other, could be packed together in a line only one inch long. All the molecules in a cubic inch of gas would form a line which would reach 1200 times around the world. To count the collisions which only one makes with its fellows during a second's time would take the greater part of man's allotted span, even working 24 hours to the day, for there are 5,000,000,000 of them.

In talking of these very small magnitudes, special units are used, the Greek letters "μ" and "$\mu\mu$," the latter being 1,000 times smaller than the former, which is itself one-thousandth of a millimetre. There are 25 millimetres to an inch. Now the ultramicroscope can perceive particles down to $1\mu\mu$, while the size of most molecules is between $.1\mu\mu$ and $.5\mu\mu$; so that it will be seen that even with the ultramicroscope most molecules cannot be seen directly. But we can observe their actions on the larger particles which are introduced for them to buffet about, and so can calculate their sizes and speeds. However, some molecules of complex organic compounds (egg albumen, starch, pepsin, etc.) are known to be 10,000 to 20,000 times heavier than the molecule of hydrogen. They have, therefore, diameters of about $6\mu\mu$ and are within the ultramicroscopic range.

It may be asked what causes the incessant and very violent movements of the molecules of gases and liquids. We do not know! All we can reply is that they undoubtedly do move, and that many important properties of the gases or liquids depend on this movement. The movement is more rapid the hotter the gas or liquid becomes; this accounts both for the pressure of a gas and for the evaporation of a liquid, and for many other every-day phenomena. But notwithstanding all this, we have no knowledge of the primary cause of the movements of the molecules.

From the figures given it might be supposed that molecules are so small that it would be foolish to seek a smaller subdivision of matter. This is not so. Molecules are built up of smaller particles still, called atoms. The manner in which these atoms are combined within the molecules has been the theme of numerous discussions and endless theories. One of these likens a molecule to a little solar system, of which the atoms are the component parts. Accordingly the molecule of mercury vapor, which consists of a single atom, would be likened to a solitary sun; while that of hydrogen and many other gases would be what is called in astronomy a "binary star," consisting of two atoms revolving round a common center. The molecule of sulphuric acid is analogous to a more complicated solar system. Round a central "sun" consisting of an atom of sulphur revolve four "planets" of oxygen. Of these, two have "moons" of hydrogen revolving round them in orbits similar to our own moon's. The whole system is represented by the molecular formula (HO), SO, or H_2SO_4. So we might go on until we arrived at the tremendously complicated molecules of organic chemistry. Under this theory a chemical reaction might be compared to the cosmic catastrophe that would ensue if two mighty solar systems came each within the other's sphere of influence. In the resulting meleé new systems would be formed from the débris of the old, and the new-born combinations would rush away into space. This is precisely what occurs when one chemical reagent is added to another. Even in the commonest and simplest of every-day phenomena, in breathing and eating and drinking, old systems perish and new ones are formed.

It might be imagined that with the atom we have

really reached the ultimate form in which matter exists, but spectrum analysis and physical chemistry prove that an atom is in itself of a very complex nature. It has repeatedly been demonstrated that certain heavy atoms, such as radium, uranium, etc., break up spontaneously, and yield still smaller bodies. These have received the name of electrons, and are supposed to be about 1/1800th the weight of the lightest known atom—that of hydrogen. By parting with these electrons certain of the atoms (of which there are known altogether eighty-three) are believed to be transformed into atoms of other elements, and these again into lighter atoms still. In some cases the transformation is exceedingly rapid; sometimes a fraction of a second is sufficient to complete the change. In other instances the action is very slow, occupying thousands of years.

This transformation of one element into another by atomic disintegration has led to the theory that the whole of the elements have at one time been formed from a parent element, and that a slow but sure degradation of the elements is in progress. On this theory, calculations as to the probable life of the world have been made, but the data are too scanty to warrant much faith in the estimations. The slow transformation of one element into another, to effect which was the whole aim of alchemy, is now well demonstrated. but it does not yet seem feasible to put the phenomenon to a practical use. The transformation is attended by the release of a very large amount of energy, and, could a means be found to hasten the process, the world would have a tremendous, and it must be feared, a terrible source of power. The logical conclusion to the discovery of such a means is well worked out by the imaginative powers of Mr. H. G. Wells in his book "*The World Set Free*." Such a terrible agent of destruction would be at hand that the world would be forced to abandon its wars to protect itself from its own folly. Such results, however, are happily at present only in the realms of imagination. That the study of the smallest particles of matter is by no means a dry and uninteresting science, but a peering into an active, throbbing universe, is sufficiently evident from the facts quoted, without the aid of fiction.

Black Locust Needed for Ships

THE revival of the wooden-ship industry has occasioned a considerable demand for black locust wood for "treenails" which are used to fasten the planking to the ribs of the ship. Black locust originally occurred only along the Appalachian Mountains and on the adjacent highlands, from Pennsylvania to Georgia, but it has spread until it now is found in merchantable sizes over a large area. The wood is very hard and close grained and is one of the most durable hard woods known, particularly when in contact with the soil or in other moist situations.

In supplying black-locust wood for shipbuilding purposes it is very important, experts of the Forest Service say, to be able to distinguish it from that of the honey locust, a tree quite similar in many respects but whose wood has a coarser grain and is of inferior quality. The danger of selecting the wrong tree is increased by the fact that in some localities the names applied are exactly reversed, the honey locust being known exclusively as black locust and the true black locust being known as honey locust.

In the case of both trees the leaves are of the compound type, that is they are composed of a number of small leaflets arranged along the central leaf-stalk. The true black locust (which is known botanically as *Robinia pseudacacia*) has leaflets with smooth or entire margins. The leaves of the honey locust (*Gleditsia triananthus*), however, are shallow-toothed or scalloped along the edges, particularly towards the ends.

The character of the thorns also furnishes a dependable means of identification. The thorns of the black locust are short and arranged in pairs. Those of the honey locust, on the other hand, are frequently several inches in length, are often divided into three or more branches, and may be produced in great quantities. They often occur in dense clusters along the main trunk of the tree. The seed pods are also distinctive. Those of the honey locust are, as a rule, from ten to eighteen inches long, while the pods of the black locust are shorter and usually measure from two to four inches.

To the experienced woodsman all of these features, of course, are very familiar, as is also the characteristic appearance of the black locust caused by the attacks of an insect known as the locust borer, which causes a characteristic swelling of the branches.

The officials of the Forest Service at Washington will identify specimens without charge. They point out that samples of leaves, twigs and fruits are always more dependable as a means of identification than the wood itself.

—*American Forestry.*

Comparing and Setting Clocks*
A Short Method of Utilizing Coincidence of Beats
By Charles Clayton Wylie

THE method described in this paper of making and reducing chronograph comparisons of clocks running on Standard Time and Sidereal Time is practically what has been developed by the members of the staff of the U. S. Naval Observatory connected with the Time Service. The method of making and reducing comparisons by coincidence of beats was developed by the writer to secure the same simplicity for eye and ear work. Now that the government officials cannot permit private wireless sets with which to receive accurate time from the U. S. Naval Observatory, independent determination of time is of greater value. Perhaps most astronomical observatories have as their best timepiece a sidereal clock. Some have two good clocks, one a Mean Time, the other a Sidereal. Where there is choice it is preferable to adopt the Sidereal as the standard and set the Mean Time clock by it. The Mean Time can then be kept within a fraction of a second of true Standard Time, and this will help wonderfully in securing the reputation of the observatory as a place of accurate time.

Where a record is desired for scientific purposes, as with the signals sent from this observatory, chronograph work is customary; but practically the same accuracy can be attained by eye and ear. Some results of the writer to test the accuracy of the method give, as the probable error of a single comparison by coincidence of beats, ±0.008 seconds. The probable error of a setting by coincidence seems to be about twice that of a comparison. It is doubtful if the performance of many clocks warrants the expenditure of much care to reach even this accuracy. To ascertain the advantage of the method of reduction here presented, the writer, with Mr. Ernest Clare Bower of this observatory, prepared and reduced a number of comparisons by coincidence of beats, both as ordinarily taken and as suggested in this paper. The average time for reduction by the short method was 45 per cent. of the average time for reduction by the regular methods. In practice the reduction of a comparison by coincidence may often be practically completed while waiting for the coincidence to occur.

COMPARISONS BY CHRONOGRAPH

Let us consider the following example: On February, 1917, 10.9 at the U. S. Naval Observatory, Seth Thomas clock No. 100 keeping Eastern Standard Time was compared with Howard clock No. 404 keeping Local Sidereal Time, by chronograph, as follows: Seth Thomas 23 hr. 33 min. 00.0 sec. = Howard 20 hr. 49 min. 40.95 sec. The correction to Howard No. 404 was—15.06 sec. Find the correction to Seth Thomas No. 100.

A good explanation of the usual method of reduction can be found in Campbell's Practical Astronomy, page 22. We will modify this somewhat:

(1)

(a) Greenwich Sidereal Time Mean Noon Feb. 11.21	23	54.47	
(b) Change in 5h. Table III		49.28	
(c) 75th Meridian Sidereal Time of 75th Meridian Mean Noon	21 24	43.75	(c=a+b)
(d) Longitude Washington from 75th Meridian	8	15.78	
(e) Washington Sidereal Time of 75th Meridian Mean Noon	21 16	27.97	(e=c—d)
(f) Correction to Howard, No. 404		—15.06	
(g) Howard No. 404 Time of 75th Meridian Mean Noon	21 16	43.03	(g=e—f)
(h) Given Howard Sidereal Time	20 49	40.95	
(i) Mean Time interval to Seth Thomas Noon	27	00.00	
(k) Table III, argument 27 min.		4.44	
(m) Howard No. 404 Time of Seth Thomas Noon	21 16	45.39	(m=h+i+k)
(g) Howard No. 404 Time of 75th Meridian Mean Noon	21 16	43.03	(see above)

(n) Correction to Seth Thomas	+2.36	(n=m—g)

In looking at the reduction we see that (b) and (d) are constant for any particular observatory, and may be combined to obtain (e) in one operation. This quantity should be obtained and kept for use whenever clocks are compared. It is the reduction to apply to *Greenwich Sidereal Time of Mean Noon*, to obtain *Local Sidereal Time of Standard Time Noon*. For the Naval Observatory this quantity is —7 min. 26.50 sec. Though it is not obtained in the above problem it will be obvious to the reader that for a given place the reduction to apply to Greenwich Sidereal Time of Mean Noon to obtain the Local Sidereal Time of any hour of Standard Time is constant. For example, the reduction for 10 P. M. at this observatory is + 9 hr. 54 min. 12.07 sec. So for simplicity in reduction as well as in carrying forward clock rates the comparisons should be made at about the same time each day. If 11 A. M. to Noon is convenient, keep the reduction to Local Sidereal Time of Noon. If 8 A. M. to 9 A. M. is more convenient, obtain and preserve for use the reduction to Local Sidereal Time of 9 A. M.

By taking comparisons always on the beginning of a minute of the Standard Time clock the only part of Table III utilized, after obtaining reduction mentioned in preceding paragraph, is the first column. We see also that with this form of reduction the column of seconds is not affected by dropping the work for the minutes and hours. The correction is generally known to be only a few seconds—usually the minute can be checked by comparing with another Standard Time clock. By these considerations we condense the work to the following:

(2)

(a) Greenwich Sidereal Time Mean Noon February 11	54.47	
(b+d) Reduction to Washington Sidereal Time of 75th Meridian Mean Noon.	—26.50	
(e) Washington Sidereal Time of 75th Meridian Mean Noon	27.97	
(f) Correction to Howard No. 404	—15.06	
(g) Howard No. 404 Time of 75th Meridian Mean Noon	43.03	
(h) Given Howard Sidereal Time	40.95	
(k) Table III, argument 27 minutes	+ 4.44	
(m) Howard No. 404 Time of Seth Thomas Noon	45.39	
(g) Howard No. 404 Time of 75th Meridian Mean Noon	43.03	
(n) Correction to Seth Thomas	+ 2.36	

Where daily comparisons are made the quantity (e), or its equivalent the Sidereal Time of the proper Standard Time hour, may be entered months ahead. Several months may be entered from the Ephemeris in a few moments. If a copy of the first column of Table III is kept handy on a small piece of cardboard or heavy paper it will be unnecessary to open an Ephemeris in making and reducing a comparison. It is obvious that, having obtained the quantity (g), several Mean Time clocks may be compared or several comparisons of the same one made with slight additional labor. The reduction after this point is hardly more than a mental process.

COMPARISONS BY EYE AND EAR

Where a high degree of accuracy is not sought, an eye and ear comparison is made by noting the second and estimated tenth of second the Sidereal clock reads on the beginning of a minute of the Standard Time clock, or when the latter reads zero seconds. The reductions are made as with chronograph work (see form 2), but only to the tenth of second. Where greater accuracy is desired the reading of the Standard Time clock at time of coincidence of beats with the Sidereal is also taken. To understand the method of reduction suggested, see form (1), and consider the quantities (h), (i), (k), and (m). In general when

(h)=Reading of Sidereal clock at time of comparison,
(i)=Mean Time interval to next hour by Mean Time clock,
(k)=Table III, argument (i),
(m)=Reading of Sidereal clock at the next hour by Mean Time clock,

we may say, neglecting the rates of the two clocks,

$$(h) + (i) + (k) = (m).$$

Now if the clocks are in exact coincidence the decimal of second of the quantities (h) and (i) must be zero.

The decimal of second of (m) must therefore be identical with that of (k), the quantity from Table III. We may then obtain the value of (m) more accurately by noting the reading of the Standard Time clock at time of coincidence, forming the interval to next hour, and with this as argument entering Table III for the decimal part of (m).

The following example will illustrate the method of comparing and reducing when the accuracy of coincidence of beats is desired: An observatory, Longitude West 6 hr. 9 min. 18.33 sec., has a clock running on Local Sidereal Time, and two clocks, Clock A and Clock B, running on Central Standard Time. The clocks are compared between 8 A. M. and 9 A. M. and the constant reduction from Greenwich Sidereal Time of Mean Noon to Local Sidereal Time of Central Standard Time 9 A. M. (or 21 hr.) is + 20 hr. 55 min. 7.80 sec. On July, 1917, 4.9 the correction to the Sidereal clock is —30.41 seconds and

M. T. A 30 min. 0.0 seconds=Sidereal 13.8 seconds.
M. T. B 31 min. 0.0 seconds=Sidereal 16.1 seconds.
M. T. A Coincidence with Sidereal=31 min. 6 sec.
M. T. B Coincidence with Sidereal=30 min. 15 sec.
Find corrections to Mean Time clocks A and B.

(3)

		Clock A	Clock B
(a)	Greenwich Sid. Time Mean Noon July 4.	41.88	
(b+d)	Reduction to Local Sid. Time of C. S. T. 9 A. M.,	+ 7.80	
(e)	Local Sid. Time of C. S. T. 9 A. M.,	49.68	
(f)	Correction to Sid. Clock,	—30.41	
(g)	Sid. Clock Time of C. S. T. 9 A. M.,	20.09	
(h)	Given Sid. Clock Time,	13.8	16.1
(k)	Table III, (30 m),	4.9	(29m) 4.8
(m)	Sid. Clock Time of Clock 9 A. M.,	(18.7)	(20.9)
		18.75	20.89
(g)	Sid. Clock Time of C. S. T. 9 A. M.,	20.09	20.09
(n)	Correction to M. T. Clocks,	— 1.34	+ 0.80

Up to step (m) the reductions are made as for chronograph comparisons (see form (2)), but only to one decimal in steps (h), (k) and (m). This rough value of (m) is bracketed and the more exact value obtained from Table III. The times of coincidence are for Clock A 31 min. 6 sec., and for Clock B 30 min. 15 sec.; so we enter the table with arguments 28 min. 54 sec. and 29 min. 45 sec., thereby obtaining the decimals .75 and .89 which are entered in place of the values in brackets. No attention is paid to the whole number of seconds in the table as that is already known.

SETTING A CLOCK

When comparisons are taken on the chronograph one can change the correction of a clock by causing the pendulum to swing more rapidly or more slowly as may be necessary. An expert, finding a clock a tenth of a second in error either way, can thus correct it by hand so that repeated comparisons show the hundredth of second as desired. But quick setting in this manner requires a certain amount of natural skill and considerable practice. The clocks used for sending out the Naval Observatory Time Signals are each equipped with an electromagnetic setting device. A permanent magnet attached to the pendulum swings over a solenoid. A current in one direction through the solenoid will attract the magnet, and in the reverse direction will repel the magnet. By this device the clock can be given a gaining or losing rate of about 0.05 seconds per minute; so that, for example, an error of 0.15 seconds can be corrected in three minutes.

For those with no special device for setting, a simple and accurate way of getting a clock on true Standard Time is suggested by the method of comparing by coincidence of beats described earlier in this paper. Set the Mean Time clock so that the beginning of its minute comes at the proper second by the Sidereal clock. The fraction of the second may be made nearly correct by estimating the reading of the Sidereal at the zero second of the Mean Time.

If an accurate setting is desired this is accomplished by putting the Mean Time clock in exact coincidence with the Sidereal at the proper time. For example, let us suppose it is desired to set the clocks of form (3). The reduction gave for the Sidereal clock time of C. S. T. 9 A. M., 20.09 seconds. By Table III and subtraction we get

For C. S. T. 8 hr. 34 min. A. M. a Sidereal clock reading of 15.8 sec.

For C. S. T. 8 hr. 35 min. A. M. a Sidereal clock reading of 16.0 sec.

For C. S. T. 8 hr. 36 min. A. M. a Sidereal clock reading of 16.1 sec.

For those minutes just after we have taken the comparisons recorded earlier in this paper the second hands of the Mean Time clocks should read 0.0 when the second hand of the Sidereal reads about 16.0. To set. hold Clock A back about a second to approximate coincidence with the Sidereal, and accelerate Clock B about a second, also to approximate coincidence. If this is done with ordinary care they will now be correct within one- or two-tenths of a second. For .09 we obtain by interpolation from the first column of Table III a coincidence at 35 minutes 6 seconds, and another at 41 minutes 11 seconds. One Mean Time clock may be carefully put in coincidence at 35 minutes 6 seconds, if ready then; or if not, at 41 minutes 11 seconds. When it is accurately set the other Mean Time can be set in coincidence with it. It is unnecessary to set both by the Sidereal, though that may be done and the two Mean Times then compared with one another as a check on the accuracy of the work.

GENERAL REMARKS

The details of the operations have been outlined in the preceding paragraphs, and some general notes which may be found useful will be added here. The first column of Table III of the Ephemeris is constantly used in the methods of this paper. Since it is the only part of the Ephemeris ordinarily used it should be copied in convenient form. Using the Table as in the Ephemeris one looks up a correction with the number of minutes until the next hour as argument. It has been found more convenient to have as argument the face reading of the clock at time of comparison. That is, if a comparison be taken at 23 hr. 35 min., one would look in Table III of the Ephemeris under 25 minutes. In our table we take out the correction with argument 35 minutes, the face reading of the clock. The face reading table is especially convenient in coincidence work, where the argument includes both minutes and seconds. It may be added that the third decimal is dropped in the copies of the table in use here. This paper has been prepared with the Table III arguments as given in the Ephemeris to avoid confusing the reader.

A theoretical objection to this method of comparison is that it gives the correction to a Mean Time clock in terms of Sidereal seconds. This can, of course, be allowed for, but the error introduced is less than a hundredth of a second, for a clock correction of three seconds, and, those interested in high accuracy will probably keep the correction well below that by setting and regulating. This objection does not apply to the method of setting suggested, as the correction to the Mean Time clock is not used.

It may also be remarked that frequent setting of a clock by the method of coincidence will be found simpler and more satisfactory than the method, quite generally practiced a few years ago, of keeping the clock approximately correct without setting, by adding to or removing from the pendulum small weights. Many members of the staff of this observatory have in former years used that method of keeping a clock on the correct time, but none now do. It keeps the rate of a clock variable and somewhat uncertain. The standard clocks here, sealed and in a constant temperature vault, are, in general, disturbed only for cleaning; but a dozen other high grade clocks, both Sidereal and Mean Time, which show accurate time over the institution are frequently set. Setting a clock appears to have no appreciable effect on its rate provided one is careful to leave the pendulum swinging at its normal amplitude. An abnormal amplitude may cause an abnormal rate, until the pendulum returns to its normal amplitude.

In conclusion we give some settings of a Mean Time clock made by Mr. C. B. Watts of this observatory to test the accuracy of the coincidence method. The procedure was to get the Mean Time clock beating as accurately as possible in coincidence with the Sidereal at the proper time to give the "indicated" reading. In a minute to a minute and a half the two clocks would be sufficiently out of beat to permit comparison

on the chronograph. A comparison was then made and the "recorded" reading obtained. The difference between the "indicated" reading, at which it was attempted to set the clock, and the "recorded" reading which the comparison on the chronograph showed, was taken as the error of that setting. These settings were made on the afternoon of 1917, October 9. Only the decimal of the second is given.

Indicated	Recorded	Error	Indicated	Recorded	Error
.97 sec.	.96 sec.	.01 sec.	.31 sec.	.30 sec.	.01 sec.
.82	.79	.03	.33	.32	.01
.53	.54	.01	.04	.01	.03
.13	.13	.00	.72	.73	.01
.23	.27	.04	.83	.85	.02

These results give as the probable error of a single setting by coincidence, ±0.015 seconds. Errors in the record, in the running of the chronograph, in the break circuit wheels of the clocks, etc., cause a probable error in a single comparison of the clocks used of about ±0.006 seconds. This probable error is included in that given above for a single setting by coincidence.

Special Properties of Eutectoid Steel

FROM a study of different carbon steels, having lamellar or granular, pearlitic structures, it is concluded that, in physical properties, eutectoid steel is differentiated sharply from other steels of similar composition. In eutectoid steel, the hardness, resistivity, and resistance to rupture and compression are at the maxima after annealing the lamellar pearlite not being rendered granular by heating at 700° C. for 7 hours. A rectilinear diagram is not applicable for representing the physical properties of iron-carbon alloys in the eutectoid region. These properties are probably associated with the high degree of dispersion (i. e., ratio of surface to volume) of the metal in the eutectoid region of the iron-carbon series. From a note in *Jour. Soc. Chem. Ind.* on an article by P. Y. SALDAU in *Rev. Soc. russe de Mét.*

Depolymerization and Oxidation of Raw Rubber

WHEN rubber is worked on normally heated rolls the most marked decrease in viscosity occurs in the first ten minutes, but on prolonged treatment, e. g., for 80 minutes, it is found that first latex crêpe rubbers of different initial viscosity appear to tend towards identical final viscosity, which on account of its diminution is best estimated in 10 per cent solution. Experiments with raw Congo rubber indicate that washing with cold water and subsequent drying effect a considerable decrease in the viscosity; the method of drying is of influence, the use of a vacuum desiccator yielding the most trustworthy results. Experiments with hard fine Para rubber showed that although working on the rolls beyond the normal period of ten minutes causes a decided further decrease in viscosity, the proportion of constituents soluble in acetone remains unaltered throughout, the only marked change in composition being a reduction in the proportion of moisture present. Rubber undergoes "depolymerization" also when heated in solution (see Van Rossem, this J., 1917, 1104) or in the solid state, and this probably accounts for the fact that on drying rubber *in Vacuo* at 50 degrees C., a greater reduction in viscosity is observed than when the drying is effected at the ordinary temperature. It was also found that subsequent storage for 13 days did not restore the original viscosity but actually caused a slight further decrease. These tests were made with Congo rubber. If rubber (Hevea crêpe in the experiments cited) is heated at 130 degrees or 140 degrees C. in an atmosphere of carbon dioxide for several hours, the viscosity undergoes very marked reduction, but unlike the original rubber, the heated rubber is not completely soluble in benzine and the insoluble fraction probably contains some of the more viscous constituents; heating in air at 80 degrees C. also causes a diminution in viscosity but the decrease is less marked, probably because the treated rubber obtained under these conditions is entirely soluble in benzine. In any case this effect of heat on the mechanical properties of rubber deserves serious consideration in connection with the ordinary process of smoking freshly coagulated rubber. The depolymerization of rubber can also be accelerated by exposing solutions to ordinary or ultraviolet light, whether in the presence of air or of an inert gas; chemical influences can be active in this direction, the viscosity of rubber solutions being notably reduced on treatment with potassium permanangate (Harries, this J., 1904, 830), with small quantities of an acid, with bromine, or, at higher temperatures, with oxygen, the effect apparently being catalytic. When a Hevea rubber which has been worked on the rolls is kept for 20 days there is a slight increase in the viscosity, but after such storage further treatment on the rolls has a very unfavorable influence on the viscosity; much higher

viscosity values were obtained with a rubber-sulphur mixing which immediately after the first treatment on the rolls was passed a further ten times between the rolls, than with a part of the same mixing which was given a similar additional treatment but on the following day: the frequent practice of storing masticated rubber for a period and then re-masticating therefore appears to be detrimental. With respect to the oxidation of rubber, the view is held that this is a secondary process which can only occur after previous depolymerization to a definite critical viscosity, and the oxidation process is believed to involve the intermediate formation of peroxide compounds. The injurious action of copper compounds on rubber is confirmed and is regarded as due to a depolymerizing effect rather than to a process of oxidation.—Note in *Jour. Soc. Chem. Ind.* on a report by A. VAN ROESSEM in Communications of the Netherlands Govt. Inst. for Advising the Rubber Trade and Rubber Industry.

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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